

5 **POLYNUCLEOTIDE ENCODING TWO NOVEL HUMAN POTASSIUM**
CHANNEL BETA-SUBUNITS, K+betaM4 and K+betaM5

This application claims benefit to provisional application U.S. Serial No. 60/272,190 filed February 28, 2001; and to provisional application U.S. Serial No. 60/274,258, filed March 7, 2001. The entire teachings of the referenced applications are incorporated herein by reference.

FIELD OF THE INVENTION

The present invention provides novel polynucleotides encoding K+betaM4 polypeptides, fragments and homologues thereof. Also provided are vectors, host cells, antibodies, and recombinant and synthetic methods for producing said polypeptides. The invention further relates to diagnostic and therapeutic methods for applying these novel K+betaM4 polypeptides to the diagnosis, treatment, and/or prevention of various diseases and/or disorders related to these polypeptides. The invention further relates to screening methods for identifying agonists and antagonists of the polynucleotides and polypeptides of the present invention.

BACKGROUND OF THE INVENTION

Voltage-gated potassium channels are a large and diverse family of proteins critical for the regulation of resting membrane potential in nearly all cell types. The importance of these proteins in the maintenance of cellular homeostasis is highlighted by the fact that defective potassium channels have been implicated in several human diseases, myokymia, long QT syndrome, epilepsy, and Bartter's syndrome (Ackerman and Clapham, 1997). Potassium channels are classified in various functional categories by the number of transmembrane domains (Jan and Jan, 1997).

A large class of channels, the outward rectifiers, contains 6 transmembrane domains. Within this family are six subfamilies of alpha chains designated Kv1-6. These alpha chains are functional as monomers and in some classes as multimers. In addition, potassium channels can undergo hetero-multimerization with a class of alpha subunits, which by themselves do not form functional channels (Salians et al.,

5 1997). These proteins, when expressed at high levels, inhibit Kv2 channels and when expressed at lower levels, shift the voltage dependence of inactivation.

Another class of subunits, referred to as beta subunits, have also been shown to associate with alpha chains. At least 3 Kv4 beta subunits (KchIP1, 2, and 3) have been described that bind intracellular calcium ions and interact with the cytoplasmic
10 amino termini of Kv4 to modulate the channel density, inactivation kinetics, and rate of recovery from inactivation (An et al., 2000). Based upon immunohistochemical and immunoprecipitation data, these beta subunits were shown to preferentially associate with Kv4 alpha subunits and to be integral components of the native Kv4 channel complex.

15 All three of the KchIP beta subunits contain EF-hand calcium binding domains and have been shown to bind calcium in filter overlay assays. Moreover, the alpha subunit binding is localized in a highly conserved 185 amino acid core sequence, as opposed to the variable N-termini.

Similar to the outward rectifier family members, the MaxiK large-
20 conductance voltage and calcium-dependent potassium channel also contains six transmembrane segments. The rate of MaxiK channel opening and closing is dependent on the concentration of intracellular calcium. The presence or absence of its regulatory beta subunit, which contains one transmembrane domain, can further regulate this calcium-dependency by increasing calcium sensitivity (O.B., McManus
25 et al., Neuron 14:645 (1995); and P. Meera et al., FEBS Lett. 382:84 (1996)). This beta subunit, found in a tissue-restricted pattern, makes the channel more active at higher calcium levels. In addition, the estrogen hormone estradiol, has been shown to bind to MaxiK channels only when the beta-subunit is present, leading to a sexually dimorphic mechanism of MaxiK regulation (Valverde et al., 2000). The presence of
30 the regulatory beta subunit appears to induce a conformational change in the MaxiK channel creating an external estradiol binding site that enables estradiol to mediate effects through the MaxiK channel.

The potassium channel formed by the KCNQ1 alpha-subunit can bind several different beta-subunits in a tissue specific manner. One subunit, KCNE3, has been
35 shown to result in a constitutively open channel upon binding to KCNQ1 (Schroeder et al., 2000).

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5 Characterization of the K+beta5 polypeptide of the present invention led to the determination that it is involved in negatively modulating the NFkB pathway, either directly or indirectly.

Mammals have a complex immune response that relies on innate and adaptive immune pathways, and these pathways share similar classes of molecules. Most components of innate immunity are evolutionarily conserved from *Drosophila* to man,
10 while only higher eukaryotes have acquired immunity (Silverman and Maniatis, 2001). Insects have a potent and rapid response to a broad spectrum of pathogens. Fungal and bacterial infections of *Drosophila* lead to transcriptional activation of antimicrobial peptide (AMP) genes. Induction of each AMP gene is regulated by a
15 balance of inputs that are manifested by combinations of the three Rel/ NF-κB proteins- Relish, Dorsal and Dif. The AMP AttacinD gene is regulated by activation of Relish homodimers or heterodimers of Relish and Dorsal (Han and Ip, 1999). Activation of Rel/ NF-κB pathways are essential for the *Drosophila* innate immune response. For example, *Drosophila* mutations in the Relish gene do not express certain
20 classes of antimicrobial peptides and are susceptible to gram-negative bacterial infection (Hedengren et al., 1999)

Drosophila Rel proteins, like mammalian Rels, are sequestered in the cytoplasm as a result of association with an IκB-like inhibitor protein. When cells are activated by pathogens, signaling pathways are activated leading to the degradation of
25 IκB, nuclear translocation of Rel proteins and Rel activated transcription (Silverman and Maniatis, 2001). Cactus is the IκB protein that inhibits Dorsal and Dif. Relish is the mammalian homologue of p105 NF-κB, and like NF-κ-B, Relish contains both a Rel domain and a IκB inhibitory domain. Relish is activated by a cleavage event that releases the IκB domain (Stoven et al., 2000).

30 Using the above examples, it is clear the availability of novel cloned potassium channel beta subunits provides opportunities for adjunct or replacement therapy, and are useful for the identification of potassium channel beta subunit agonists, or stimulators (which might stimulate and/or bias potassium channel action), as well as, in the identification of potassium channel beta subunit inhibitors. All of
35 which might be therapeutically useful under different circumstances.

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5 The present invention also relates to recombinant vectors, which include the isolated nucleic acid molecules of the present invention, and to host cells containing the recombinant vectors, as well as to methods of making such vectors and host cells, in addition to their use in the production of K+betaM4 and K+betaM5 polypeptides or peptides using recombinant techniques. Synthetic methods for producing the polypeptides and polynucleotides of the present invention are provided. Also provided
10 are diagnostic methods for detecting diseases, disorders, and/or conditions related to the K+betaM4 and K+betaM5 polypeptides and polynucleotides, and therapeutic methods for treating such diseases, disorders, and/or conditions. The invention further relates to screening methods for identifying binding partners of the polypeptides.

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BRIEF SUMMARY OF THE INVENTION

 The present invention provides isolated nucleic acid molecules, that comprise, or alternatively consist of, a polynucleotide encoding the K+betaM4 protein having the amino acid sequence shown in Figures 1A-B (SEQ ID NO:2) or the amino acid
20 sequence encoded by the cDNA clone, K+betaM4 (also referred to as 2BAC-18) deposited as ATCC Deposit Number XXXXX on XXXXX.

 The present invention provides isolated nucleic acid molecules, that comprise, or alternatively consist of, a polynucleotide encoding the K+betaM5 protein having the amino acid sequence shown in Figures 6A-C (SEQ ID NO:24) or the amino acid
25 sequence encoded by the cDNA clone, K+betaM5 (also referred to as 2BAC-3) deposited as ATCC Deposit Number XXXXX on XXXXX.

 The present invention also relates to recombinant vectors, which include the isolated nucleic acid molecules of the present invention, and to host cells containing the recombinant vectors, as well as to methods of making such vectors and host cells,
30 in addition to their use in the production of K+betaM4 polypeptides or peptides using recombinant techniques. Synthetic methods for producing the polypeptides and polynucleotides of the present invention are provided. Also provided are diagnostic methods for detecting diseases, disorders, and/or conditions related to the K+betaM4 polypeptides and polynucleotides, and therapeutic methods for treating such diseases,
35 disorders, and/or conditions. The invention further relates to screening methods for identifying binding partners of the polypeptides.

5 The present invention also relates to recombinant vectors, which include the isolated nucleic acid molecules of the present invention, and to host cells containing the recombinant vectors, as well as to methods of making such vectors and host cells, in addition to their use in the production of K+betaM5 polypeptides or peptides using recombinant techniques. Synthetic methods for producing the polypeptides and
10 polynucleotides of the present invention are provided. Also provided are diagnostic methods for detecting diseases, disorders, and/or conditions related to the K+betaM5 polypeptides and polynucleotides, and therapeutic methods for treating such diseases, disorders, and/or conditions. The invention further relates to screening methods for identifying binding partners of the polypeptides.

15 The invention further provides an isolated K+betaM4 polypeptide having an amino acid sequence encoded by a polynucleotide described herein.

 The invention further provides an isolated K+betaM5 polypeptide having an amino acid sequence encoded by a polynucleotide described herein.

 The invention further relates to a polynucleotide encoding a polypeptide
20 fragment of SEQ ID NO:2 and/or SEQ ID NO:24, or a polypeptide fragment encoded by the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to a polynucleotide encoding a polypeptide domain of SEQ ID NO:2 and/or SEQ ID NO:24 or a polypeptide domain encoded by
25 the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to a polynucleotide encoding a polypeptide epitope of SEQ ID NO:2 and/or SEQ ID NO:24 or a polypeptide epitope encoded by the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID
30 NO:1 and/or SEQ ID NO:23.

 The invention further relates to a polynucleotide encoding a polypeptide of SEQ ID NO:2 and/or SEQ ID NO:24 or the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID NO:1 and/or SEQ ID NO:23, having biological activity.

35 The invention further relates to a polynucleotide which is a variant of SEQ ID NO:1 and/or SEQ ID NO:23.

5 The invention further relates to a polynucleotide which is an allelic variant of SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to a polynucleotide which encodes a species homologue of the SEQ ID NO:2 and/or SEQ ID NO:24.

10 The invention further relates to a polynucleotide which represents the complimentary sequence (antisense) of SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to a polynucleotide capable of hybridizing under stringent conditions to any one of the polynucleotides specified herein, wherein said polynucleotide does not hybridize under stringent conditions to a nucleic acid molecule having a nucleotide sequence of only A residues or of only T residues.

15 The invention further relates to an isolated nucleic acid molecule of SEQ ID NO:2 and/or SEQ ID NO:24, wherein the polynucleotide fragment comprises a nucleotide sequence encoding a potassium channel beta subunit protein.

 The invention further relates to an isolated nucleic acid molecule of SEQ ID NO:1 and/or SEQ ID NO:23, wherein the polynucleotide fragment comprises a
20 nucleotide sequence encoding the sequence identified as SEQ ID NO:2 and/or SEQ ID NO:24 or the polypeptide encoded by the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to an isolated nucleic acid molecule of of SEQ ID NO:1 and/or SEQ ID NO:23, wherein the polynucleotide fragment comprises the
25 entire nucleotide sequence of SEQ ID NO:1 and/or SEQ ID NO:23 or the cDNA sequence included in the deposited clone, which is hybridizable to SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to an isolated nucleic acid molecule of SEQ ID NO:1 and/or SEQ ID NO:23, wherein the nucleotide sequence comprises sequential
30 nucleotide deletions from either the C-terminus or the N-terminus.

 The invention further relates to an isolated polypeptide comprising an amino acid sequence that comprises a polypeptide fragment of SEQ ID NO:2 and/or SEQ ID NO:24 or the encoded sequence included in the deposited clone.

35 The invention further relates to a polypeptide fragment of SEQ ID NO:2 and/or SEQ ID NO:24 or the encoded sequence included in the deposited clone, having biological activity.

5 The invention further relates to a polypeptide domain of SEQ ID NO:2 and/or SEQ ID NO:24 or the encoded sequence included in the deposited clone.

 The invention further relates to a polypeptide epitope of SEQ ID NO:2 and/or SEQ ID NO:24 or the encoded sequence included in the deposited clone.

 The invention further relates to a full length protein of SEQ ID NO:2 and/or
10 SEQ ID NO:24 or the encoded sequence included in the deposited clone.

 The invention further relates to a variant of SEQ ID NO:2 and/or SEQ ID NO:24.

 The invention further relates to an allelic variant of SEQ ID NO:2 and/or SEQ ID NO:24. The invention further relates to a species homologue of SEQ ID NO:2
15 and/or SEQ ID NO:24.

 The invention further relates to the isolated polypeptide of of SEQ ID NO:2 and/or SEQ ID NO:24, wherein the full length protein comprises sequential amino acid deletions from either the C-terminus or the N-terminus.

 The invention further relates to an isolated antibody that binds specifically to
20 the isolated polypeptide of SEQ ID NO:2 and/or SEQ ID NO:24.

 The invention further relates to a method for preventing, treating, or ameliorating a medical condition, comprising administering to a mammalian subject a therapeutically effective amount of the polypeptide of SEQ ID NO:2 and/or SEQ ID NO:24 or the polynucleotide of SEQ ID NO:1 and/or SEQ ID NO:23.

25 The invention further relates to a method of diagnosing a pathological condition or a susceptibility to a pathological condition in a subject comprising the steps of (a) determining the presence or absence of a mutation in the polynucleotide of SEQ ID NO:1 and/or SEQ ID NO:23; and (b) diagnosing a pathological condition or a susceptibility to a pathological condition based on the presence or absence of said
30 mutation.

 The invention further relates to a method of diagnosing a pathological condition or a susceptibility to a pathological condition in a subject comprising the steps of (a) determining the presence or amount of expression of the polypeptide of of SEQ ID NO:2 and/or SEQ ID NO:24 in a biological sample; and diagnosing a
35 pathological condition or a susceptibility to a pathological condition based on the presence or amount of expression of the polypeptide.

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5 The invention further relates to a method for identifying a binding partner to the polypeptide of SEQ ID NO:2 and/or SEQ ID NO:24 comprising the steps of (a) contacting the polypeptide of SEQ ID NO:2 and/or SEQ ID NO:24 with a binding partner; and (b) determining whether the binding partner effects an activity of the polypeptide.

10 The invention further relates to a gene corresponding to the cDNA sequence of SEQ ID NO:1 and/or SEQ ID NO:23.

 The invention further relates to a method of identifying an activity in a biological assay, wherein the method comprises the steps of expressing SEQ ID NO:1 and/or SEQ ID NO:23 in a cell, (b) isolating the supernatant; (c) detecting an activity
15 in a biological assay; and (d) identifying the protein in the supernatant having the activity.

 The invention further relates to a process for making polynucleotide sequences encoding gene products having altered SEQ ID NO:2 and/or SEQ ID NO:24 activity comprising the steps of (a) shuffling a nucleotide sequence of SEQ ID NO:1 and/or
20 SEQ ID NO:23, (b) expressing the resulting shuffled nucleotide sequences and, (c) selecting for altered activity as compared to the activity of the gene product of said unmodified nucleotide sequence.

 The invention further relates to a shuffled polynucleotide sequence produced by a shuffling process, wherein said shuffled DNA molecule encodes a gene product
25 having enhanced tolerance to an inhibitor of SEQ ID NO:2 and/or SEQ ID NO:24 activity.

 The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
30 condition is a hepatic disorder

 The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
 condition is a neural disorder.

35 The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2

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5 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a disorder related to aberrant calcium regulation.

The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
10 condition is a reproductive disorder.

The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a gastrointestinal disorder.

15 The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a hematopoietic disorder.

The invention further relates to a method for preventing, treating, or
20 ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is an immune disorder.

The invention further relates to a method for preventing, treating, or
ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2
25 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is an inflammatory disorder.

The invention further relates to a method for preventing, treating, or
ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2
and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
30 condition is disorder related to aberrant NFkB regulation.

The invention further relates to a method for preventing, treating, or
ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2
and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
condition is a disorder related to aberrant apoptosis regulation.

35 The invention further relates to a method for preventing, treating, or
ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2

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5 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a proliferative disorder.

The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical
10 condition is a metabolic disorder.

The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a disorder related to hyper potassium channel activity.

15 The invention further relates to a method for preventing, treating, or ameliorating a medical condition with the polypeptide provided as SEQ ID NO:2 and/or SEQ ID NO:24, in addition to, its encoding nucleic acid, wherein the medical condition is a proliferative immune disorder, such as, for example leukemia, lymphomas, or multiple myeloma.

20 The invention further relates to a method of identifying a compound that modulates the biological activity of K+betaM4 and/or K+betaM5, comprising the steps of, (a) combining a candidate modulator compound with K+betaM4 and/or K+betaM5 having the sequence set forth in one or more of SEQ ID NO:2; and measuring an effect of the candidate modulator compound on the activity of
25 K+betaM4 and/or K+betaM5.

The invention further relates to a method of identifying a compound that modulates the biological activity of a potassium channel beta subunits, comprising the steps of, (a) combining a candidate modulator compound with a host cell expressing K+betaM4 and/or K+betaM5 having the sequence as set forth in SEQ ID NO:2; and ,
30 (b) measuring an effect of the candidate modulator compound on the activity of the expressed K+betaM4 and/or K+betaM5.

The invention further relates to a method of identifying a compound that modulates the biological activity of K+betaM4 and/or K+betaM5, comprising the steps of, (a) combining a candidate modulator compound with a host cell containing a
35 vector described herein, wherein K+betaM4 and/or K+betaM5 is expressed by the

- 5 cell; and, (b) measuring an effect of the candidate modulator compound on the activity of the expressed K+betaM4 and/or K+betaM5.

The invention further relates to a method of screening for a compound that is capable of modulating the biological activity of K+betaM4 and/or K+betaM5, comprising the steps of: (a) providing a host cell described herein; (b) determining the biological activity of K+betaM4 and/or K+betaM5 in the absence of a modulator
10 compound; (c) contacting the cell with the modulator compound; and (d) determining the biological activity of K+betaM4 and/or K+betaM5 in the presence of the modulator compound; wherein a difference between the activity of K+betaM4 and/or K+betaM5 in the presence of the modulator compound and in the absence of the
15 modulator compound indicates a modulating effect of the compound.

The invention further relates to a compound that modulates the biological activity of human K+betaM4 and/or K+betaM5 as identified by the methods described herein.

20 BRIEF DESCRIPTION OF THE FIGURES/DRAWINGS

Figures 1A-B shows the polynucleotide sequence (SEQ ID NO:1) and deduced amino acid sequence (SEQ ID NO:2) of the novel potassium channel beta-subunit, K+betaM4, of the present invention. The standard one-letter abbreviation for amino
25 acids is used to illustrate the deduced amino acid sequence. The polynucleotide sequence contains a sequence of 1839 nucleotides (SEQ ID NO:1), encoding a polypeptide of 351 amino acids (SEQ ID NO:2). An analysis of the K+betaM4 polypeptide determined that it comprised the following features: predicted potassium channel tetramerization domain located from about amino acid 94 to about amino acid
30 192 (SEQ ID NO:12) of SEQ ID NO:2 represented by double underlining; two transmembrane domains located from about amino acid 27 to about amino acid 53 (TM1), and/or from about amino acid 234 to about amino acid 258 of SEQ ID NO:2 represented by shading.

35 **Figures 2A-B** shows the regions of identity and similarity between K+betaM4 and other electrically silent beta subunits, specifically, the human Maxi-K potassium

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5 channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov27 protein (K+Hnov27; Genbank Accession No. gi| Y34125; SEQ ID NO:4), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:5), the Drosophila CG10440 protein (CG10440; Genbank Accession No. gi|7291303; SEQ
10 ID NO:6), and a human neuroblastoma protein (neuroblastoma; Genbank Accession No. gi|12654691; SEQ ID NO:5). The alignment was performed using the CLUSTALW algorithm described elsewhere herein, as available within the Vector NTI AlignX program (CLUSTALW parameters: gap opening penalty: 10; gap extension penalty: 0.5; gap separation penalty range: 8; percent identity for alignment
15 delay: 40%; and transition weighting: 0). The darkly shaded amino acids represent regions of matching identity. The lightly shaded amino acids represent regions of matching similarity. Lines between residues indicate gapped regions for the aligned polypeptides.

20 **Figure 3** shows an expression profile of the novel human potassium channel beta-subunit, K+betaM4. The figure illustrates the relative expression level of K+betaM4 amongst various mRNA tissue sources. As shown, transcripts corresponding to K+betaM4 expressed predominately high in the liver and spinal cord. The K+betaM4 polypeptide was also expressed significantly in small intestine, testis, stomach, and to a lesser extent,
25 in heart, lymph node, uterus, kidney, and prostate. Expression data was obtained by measuring the steady state K+betaM4 mRNA levels by quantitative PCR using the PCR primer pair provided as SEQ ID NO:10 and 11 as described herein.

Figure 4 shows a table illustrating the percent identity and percent similarity between
30 the K+betaM4 polypeptide of the present invention with the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov27 protein (K+Hnov27; Genbank Accession No. gi| Y34125; SEQ ID NO:4), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:5), the
35 Drosophila CG10440 protein (CG10440; Genbank Accession No. gi|7291303; SEQ ID NO:6), and a human neuroblastoma protein (neuroblastoma; Genbank Accession No. gi|12654691; SEQ ID NO:5). The table also shows the percent identity and

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5 percent similarity between the K+betaM5 polypeptide of the present invention with the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:3), the human lung protein (MGC:2376; Genbank Accession No. gi|12654469; SEQ ID NO:25), the
10 human MSTP028 protein (MSTP028; Genbank Accession No. gi|11640564; SEQ ID NO:26); the Caenorhabditis K+ channel tetramerisation domain containing protein (K+channel_tetra; Genbank Accession No. gi|3875362; SEQ ID NO:28); and the Drosophila CG10465 protein (CG10465; Genbank Accession No. gi|7302243; SEQ ID NO:27). The percent identity and percent similarity values were determined based
15 upon the GAP algorithm (GCG suite of programs; and Henikoff, S. and Henikoff, J. G., Proc. Natl. Acad. Sci. USA 89: 10915-10919(1992)) using the following parameters: gap weight = 8, and length weight = 2.

Figure 5 shows an expanded expression profile of the novel human potassium
20 channel beta-subunit, K+betaM4. The figure illustrates the relative expression level of K+betaM4 amongst various mRNA tissue sources by TaqMan™ quantitative PCR. The expression pattern using TaqMan™ confirms and extends the earlier results obtained with SYBR green (Figure 4). As shown, K+betaM4 was expressed at low levels in most tissues tested with predominate expression in brain, testis, and adrenal
25 gland, and to a lesser extent in other tissues as shown. Expression data was obtained by measuring the steady state K+betaM4 mRNA levels by quantitative PCR using the PCR primer pair provided as SEQ ID NO:45 and 46, and Taqman probe (SEQ ID NO:47) as described in Example 5 herein.

30 **Figures 6A-C** shows the polynucleotide sequence (SEQ ID NO:23) and deduced amino acid sequence (SEQ ID NO:24) of the novel potassium channel beta-subunit, K+betaM5, of the present invention. The standard one-letter abbreviation for amino acids is used to illustrate the deduced amino acid sequence. The polynucleotide sequence contains a sequence of 2154 nucleotides (SEQ ID NO:23), encoding a
35 polypeptide of 343 amino acids (SEQ ID NO:24). An analysis of the K+betaM5 polypeptide determined that it comprised the following features: predicted potassium

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- 5 channel tetramerization domain located from about amino acid 146 to about amino acid 241 (SEQ ID NO:39) of SEQ ID NO:24 represented by double underlining; and one transmembrane domain located from about amino acid 281 to about amino acid 305 (TM1) of SEQ ID NO:24 represented by single underlining.
- 10 **Figures 7A-B** show the regions of identity and similarity between K+betaM5 and other electrically silent beta subunits, specifically, the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:3), the human lung protein (MGC:2376;
- 15 Genbank Accession No. gi|12654469; SEQ ID NO:25), the human MSTP028 protein (MSTP028; Genbank Accession No. gi|11640564; SEQ ID NO:26); the Caenorhabditis K+ channel tetramerisation domain containing protein (K+channel_tetra; Genbank Accession No. gi|3875362; SEQ ID NO:28); and the Drosophila CG10465 protein (CG10465; Genbank Accession No. gi|7302243; SEQ
- 20 ID NO:27). The alignment was performed using the CLUSTALW algorithm described elsewhere herein, as available within the Vector NTI AlignX program (CLUSTALW parameters: gap opening penalty: 10; gap extension penalty: 0.5; gap separation penalty range: 8; percent identity for alignment delay: 40%; and transition weighting: 0). The darkly shaded amino acids represent regions of matching identity.
- 25 The lightly shaded amino acids represent regions of matching similarity. Lines between residues indicate gapped regions for the aligned polypeptides.

Figure 8 shows an expression profile of the novel human potassium channel beta-subunit, K+betaM5. The figure illustrates the relative expression level of K+betaM5 amongst

30 various mRNA tissue sources. As shown, transcripts corresponding to K+betaM5 expressed predominately high in the testis. The K+betaM5 polypeptide was also expressed significantly in spinal cord, lymph node, heart, uterus, and to a lesser extent, in small intestine, stomach, prostate, and kidney. Expression data was obtained by measuring the steady state K+betaM5 mRNA levels by quantitative PCR using the PCR

35 primer pair provided as SEQ ID NO:31 and 32 as described herein.

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5 **Figure 9** shows an expanded expression profile of the novel human potassium channel beta-subunit, K+betaM5. The figure illustrates the relative expression level of K+betaM5 amongst various mRNA tissue sources by TaqMan™ quantitative PCR. The expression pattern using TaqMan™ confirms and extends the earlier results obtained with SYBR green (Figure 8). As shown, K+betaM5 was expressed at low
10 levels in with predominate expression in testis. Expression data was obtained by measuring the steady state K+betaM5 mRNA levels by quantitative PCR using the PCR primer pair provided as SEQ ID NO:48 and 49, and Taqman probe (SEQ ID NO:50) as described in Example 5 herein.

15 **Table I** provides a summary of the novel polypeptides and their encoding polynucleotides of the present invention.

Table II illustrates the preferred hybridization conditions for the polynucleotides of the present invention. Other hybridization conditions may be known in the art or are
20 described elsewhere herein.

Table III provides a summary of various conservative substitutions encompassed by the present invention.

25 DETAILED DESCRIPTION OF THE INVENTION

The present invention may be understood more readily by reference to the following detailed description of the preferred embodiments of the invention and the Examples included herein.

The invention provides a novel human sequence that potentially encodes a
30 potassium channel modulating subunit called K+betaM4. The protein encoded by the K+betaM4 cDNA possesses two putative transmembrane domains and hence belongs in the category of beta subunits that potentially modulate potassium channel function through calcium sensitivity. Such beta subunits are referred to as calcium sensing beta subunits, of which the MaxiK protein is a
35 member. Transcripts for K+betaM4 are found in the liver and spinal cord, significantly in small intestine, testis, stomach, and to a lesser extent, in heart, lymph

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5 node, uterus, kidney, and prostate, suggesting that the invention modulates potassium channel functions in these tissues.

The invention provides a novel human sequence that potentially encodes a potassium channel modulating subunit called K⁺betaM5. The protein encoded by the K⁺betaM5 cDNA possesses one putative transmembrane domain and
10 hence belongs in the category of beta subunits that potentially modulate potassium channel function through calcium sensitivity. Such beta subunits are referred to as calcium sensing beta subunits, of which the MaxiK protein is a member. Transcripts for K⁺betaM5 are found in the testis, significantly in spinal cord, lymph node, heart, uterus, and to a lesser extent, in small intestine, stomach,
15 prostate, and kidney, suggesting that the invention modulates potassium channel functions in these tissues.

In the present invention, "isolated" refers to material removed from its original environment (e.g., the natural environment if it is naturally occurring), and thus is altered "by the hand of man" from its natural state. For example, an isolated
20 polynucleotide could be part of a vector or a composition of matter, or could be contained within a cell, and still be "isolated" because that vector, composition of matter, or particular cell is not the original environment of the polynucleotide. The term "isolated" does not refer to genomic or cDNA libraries, whole cell total or mRNA preparations, genomic DNA preparations (including those separated by
25 electrophoresis and transferred onto blots), sheared whole cell genomic DNA preparations or other compositions where the art demonstrates no distinguishing features of the polynucleotide/sequences of the present invention.

In specific embodiments, the polynucleotides of the invention are at least 15, at least 30, at least 50, at least 100, at least 125, at least 500, or at least 1000
30 continuous nucleotides but are less than or equal to 300 kb, 200 kb, 100 kb, 50 kb, 15 kb, 10 kb, 7.5 kb, 5 kb, 2.5 kb, 2.0 kb, or 1 kb, in length. In a further embodiment, polynucleotides of the invention comprise a portion of the coding sequences, as disclosed herein, but do not comprise all or a portion of any intron. In another embodiment, the polynucleotides comprising coding sequences do not contain coding
35 sequences of a genomic flanking gene (i.e., 5' or 3' to the gene of interest in the genome). In other embodiments, the polynucleotides of the invention do not contain

5 the coding sequence of more than 1000, 500, 250, 100, 50, 25, 20, 15, 10, 5, 4, 3, 2, or 1 genomic flanking gene(s).

As used herein, a "polynucleotide" refers to a molecule having a nucleic acid sequence contained in SEQ ID NO:1, SEQ ID NO:23, or the cDNA contained within the clone deposited with the ATCC. For example, the polynucleotide can contain the
10 nucleotide sequence of the full length cDNA sequence, including the 5' and 3' untranslated sequences, the coding region, with or without a signal sequence, the secreted protein coding region, as well as fragments, epitopes, domains, and variants of the nucleic acid sequence. Moreover, as used herein, a "polypeptide" refers to a molecule having the translated amino acid sequence generated from the
15 polynucleotide as broadly defined.

In the present invention, the full length sequence identified as SEQ ID NO:1 and SEQ ID NO:23 was often generated by overlapping sequences contained in multiple clones (contig analysis).

Unless otherwise indicated, all nucleotide sequences determined by
20 sequencing a DNA molecule herein were determined using an automated DNA sequencer (such as the Model 373, preferably a Model 3700, from Applied Biosystems, Inc.), and all amino acid sequences of polypeptides encoded by DNA molecules determined herein were predicted by translation of a DNA sequence determined above. Therefore, as is known in the art for any DNA sequence
25 determined by this automated approach, any nucleotide sequence determined herein may contain some errors. Nucleotide sequences determined by automation are typically at least about 90% identical, more typically at least about 95% to at least about 99.9% identical to the actual nucleotide sequence of the sequenced DNA molecule. The actual sequence can be more precisely determined by other approaches
30 including manual DNA sequencing methods well known in the art. As is also known in the art, a single insertion or deletion in a determined nucleotide sequence compared to the actual sequence will cause a frame shift in translation of the nucleotide sequence such that the predicted amino acid sequence encoded by a determined nucleotide sequence will be completely different from the amino acid sequence
35 actually encoded by the sequenced DNA molecule, beginning at the point of such an insertion or deletion.

5 Using the information provided herein, such as the nucleotide sequence in Figures 1A-B (SEQ ID NO:1), a nucleic acid molecule of the present invention encoding the K+betaM4 polypeptide may be obtained using standard cloning and screening procedures, such as those for cloning cDNAs using mRNA as starting material. Illustrative of the invention, the nucleic acid molecule described in Figures
10 1A-B (SEQ ID NO:1) was discovered in a mixture of cDNA libraries derived from human brain and testis.

 The determined nucleotide sequence of the K+betaM4 cDNA in Figures 1A-B (SEQ ID NO:1) contains an open reading frame encoding a protein of about 351 amino acid residues, with a deduced molecular weight of about 47.39kDa. The amino
15 acid sequence of the predicted K+betaM4 polypeptide is shown in Figures 1A-B (SEQ ID NO:2).

 Using the information provided herein, such as the nucleotide sequence in Figures 6A-C (SEQ ID NO:23), a nucleic acid molecule of the present invention encoding the K+betaM5 polypeptide may be obtained using standard cloning and
20 screening procedures, such as those for cloning cDNAs using mRNA as starting material. Illustrative of the invention, the nucleic acid molecule described in Figures 6A-C (SEQ ID NO:23) was discovered in a mixture of cDNA libraries derived from human brain and testis.

 The determined nucleotide sequence of the K+betaM5 cDNA in Figures 6A-C
25 (SEQ ID NO:23) contains an open reading frame encoding a protein of about 343 amino acid residues, with a deduced molecular weight of about 37.64kDa. The amino acid sequence of the predicted K+betaM5 polypeptide is shown in Figures 6A-C (SEQ ID NO:24).

 A "polynucleotide" of the present invention also includes those
30 polynucleotides capable of hybridizing, under stringent hybridization conditions, to sequences contained in SEQ ID NO:1, the complement thereof, to sequences contained in SEQ ID NO:23, the complement thereof, or the cDNA within the clone deposited with the ATCC. "Stringent hybridization conditions" refers to an overnight incubation at 42 degree C in a solution comprising 50% formamide, 5x SSC (750 mM
35 NaCl, 75 mM trisodium citrate), 50 mM sodium phosphate (pH 7.6), 5x Denhardt's solution, 10% dextran sulfate, and 20 µg/ml denatured, sheared salmon sperm DNA,

5 followed by washing the filters in 0.1x SSC at about 65 degree C.

Also contemplated are nucleic acid molecules that hybridize to the polynucleotides of the present invention at lower stringency hybridization conditions. Changes in the stringency of hybridization and signal detection are primarily accomplished through the manipulation of formamide concentration (lower
10 percentages of formamide result in lowered stringency); salt conditions, or temperature. For example, lower stringency conditions include an overnight incubation at 37 degree C in a solution comprising 6X SSPE (20X SSPE = 3M NaCl; 0.2M NaH₂PO₄; 0.02M EDTA, pH 7.4), 0.5% SDS, 30% formamide, 100 ug/ml salmon sperm blocking DNA; followed by washes at 50 degree C with 1XSSPE,
15 0.1% SDS. In addition, to achieve even lower stringency, washes performed following stringent hybridization can be done at higher salt concentrations (e.g. 5X SSC).

Note that variations in the above conditions may be accomplished through the inclusion and/or substitution of alternate blocking reagents used to suppress
20 background in hybridization experiments. Typical blocking reagents include Denhardt's reagent, BLOTTO, heparin, denatured salmon sperm DNA, and commercially available proprietary formulations. The inclusion of specific blocking reagents may require modification of the hybridization conditions described above, due to problems with compatibility.

25 Of course, a polynucleotide which hybridizes only to polyA⁺ sequences (such as any 3' terminal polyA⁺ tract of a cDNA shown in the sequence listing), or to a complementary stretch of T (or U) residues, would not be included in the definition of "polynucleotide," since such a polynucleotide would hybridize to any nucleic acid molecule containing a poly (A) stretch or the complement thereof (e.g., practically
30 any double-stranded cDNA clone generated using oligo dT as a primer).

The polynucleotide of the present invention can be composed of any polyribonucleotide or polydeoxribonucleotide, which may be unmodified RNA or DNA or modified RNA or DNA. For example, polynucleotides can be composed of single- and double-stranded DNA, DNA that is a mixture of single- and double-
35 stranded regions, single- and double-stranded RNA, and RNA that is mixture of single- and double-stranded regions, hybrid molecules comprising DNA and RNA

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5 that may be single-stranded or, more typically, double-stranded or a mixture of single-
and double-stranded regions. In addition, the polynucleotide can be composed of
triple-stranded regions comprising RNA or DNA or both RNA and DNA. A
polynucleotide may also contain one or more modified bases or DNA or RNA
backbones modified for stability or for other reasons. "Modified" bases include, for
10 example, tritylated bases and unusual bases such as inosine. A variety of
modifications can be made to DNA and RNA; thus, "polynucleotide" embraces
chemically, enzymatically, or metabolically modified forms.

The polypeptide of the present invention can be composed of amino acids
joined to each other by peptide bonds or modified peptide bonds, i.e., peptide
15 isosteres, and may contain amino acids other than the 20 gene-encoded amino acids.
The polypeptides may be modified by either natural processes, such as
posttranslational processing, or by chemical modification techniques which are well
known in the art. Such modifications are well described in basic texts and in more
detailed monographs, as well as in a voluminous research literature. Modifications
20 can occur anywhere in a polypeptide, including the peptide backbone, the amino acid
side-chains and the amino or carboxyl termini. It will be appreciated that the same
type of modification may be present in the same or varying degrees at several sites in
a given polypeptide. Also, a given polypeptide may contain many types of
modifications. Polypeptides may be branched, for example, as a result of
25 ubiquitination, and they may be cyclic, with or without branching. Cyclic, branched,
and branched cyclic polypeptides may result from posttranslation natural processes or
may be made by synthetic methods. Modifications include acetylation, acylation,
ADP-ribosylation, amidation, covalent attachment of flavin, covalent attachment of a
heme moiety, covalent attachment of a nucleotide or nucleotide derivative, covalent
30 attachment of a lipid or lipid derivative, covalent attachment of phosphatidylinositol,
cross-linking, cyclization, disulfide bond formation, demethylation, formation of
covalent cross-links, formation of cysteine, formation of pyroglutamate, formylation,
gamma-carboxylation, glycosylation, GPI anchor formation, hydroxylation,
iodination, methylation, myristoylation, oxidation, pegylation, proteolytic processing,
35 phosphorylation, prenylation, racemization, selenoylation, sulfation, transfer-RNA
mediated addition of amino acids to proteins such as arginylation, and ubiquitination.

5 (See, for instance, PROTEINS - STRUCTURE AND MOLECULAR PROPERTIES, 2nd Ed., T. E. Creighton, W. H. Freeman and Company, New York (1993); POSTTRANSLATIONAL COVALENT MODIFICATION OF PROTEINS, B. C. Johnson, Ed., Academic Press, New York, pgs. 1-12 (1983); Seifter et al., Meth Enzymol 182:626-646 (1990); Rattan et al., Ann NY Acad Sci 663:48-62 (1992).)

10 "SEQ ID NO:X" refers to a polynucleotide sequence while "SEQ ID NO:Y" refers to a polypeptide sequence, both sequences identified by an integer specified in Table 1.

"A polypeptide having biological activity" refers to polypeptides exhibiting activity similar, but not necessarily identical to, an activity of a polypeptide of the present invention, including mature forms, as measured in a particular biological
15 assay, with or without dose dependency. In the case where dose dependency does exist, it need not be identical to that of the polypeptide, but rather substantially similar to the dose-dependence in a given activity as compared to the polypeptide of the present invention (i.e., the candidate polypeptide will exhibit greater activity or not
20 more than about 25-fold less and, preferably, not more than about tenfold less activity, and most preferably, not more than about three-fold less activity relative to the polypeptide of the present invention.)

The term "organism" as referred to herein is meant to encompass any organism referenced herein, though preferably to eukaryotic organisms, more
25 preferably to mammals, and most preferably to humans.

The present invention encompasses the identification of proteins, nucleic acids, or other molecules, that bind to polypeptides and polynucleotides of the present invention (for example, in a receptor-ligand interaction). The polynucleotides of the present invention can also be used in interaction trap assays (such as, for example,
30 that described by Ozenberger and Young (Mol Endocrinol., 9(10):1321-9, (1995); and Ann. N. Y. Acad. Sci., 7;766:279-81, (1995)).

The polynucleotide and polypeptides of the present invention are useful as probes for the identification and isolation of full-length cDNAs and/or genomic DNA which correspond to the polynucleotides of the present invention, as probes to
35 hybridize and discover novel, related DNA sequences, as probes for positional cloning of this or a related sequence, as probe to "subtract-out" known sequences in

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5 the process of discovering other novel polynucleotides, as probes to quantify gene expression, and as probes for microarrays.

In addition, polynucleotides and polypeptides of the present invention may comprise one, two, three, four, five, six, seven, eight, or more membrane domains.

Also, in preferred embodiments the present invention provides methods for
10 further refining the biological function of the polynucleotides and/or polypeptides of the present invention.

Specifically, the invention provides methods for using the polynucleotides and polypeptides of the invention to identify orthologs, homologs, paralogs, variants, and/or allelic variants of the invention. Also provided are methods of using the
15 polynucleotides and polypeptides of the invention to identify the entire coding region of the invention, non-coding regions of the invention, regulatory sequences of the invention, and secreted, mature, pro-, prepro-, forms of the invention (as applicable).

In preferred embodiments, the invention provides methods for identifying the glycosylation sites inherent in the polynucleotides and polypeptides of the invention,
20 and the subsequent alteration, deletion, and/or addition of said sites for a number of desirable characteristics which include, but are not limited to, augmentation of protein folding, inhibition of protein aggregation, regulation of intracellular trafficking to organelles, increasing resistance to proteolysis, modulation of protein antigenicity, and mediation of intercellular adhesion.

25 In further preferred embodiments, methods are provided for evolving the polynucleotides and polypeptides of the present invention using molecular evolution techniques in an effort to create and identify novel variants with desired structural, functional, and/or physical characteristics.

The present invention further provides for other experimental methods and
30 procedures currently available to derive functional assignments. These procedures include but are not limited to spotting of clones on arrays, micro-array technology, PCR based methods (e.g., quantitative PCR), anti-sense methodology, gene knockout experiments, and other procedures that could use sequence information from clones to build a primer or a hybrid partner.

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5 As used herein the terms “modulate” or “modulates” refer to an increase or decrease in the amount, quality or effect of a particular activity, DNA, RNA, or protein.

Polynucleotides and Polypeptides of the Invention

10

Features of the Polypeptide Encoded by Gene No:1

The polypeptide of this gene provided as SEQ ID NO:2 (Figures 1A-B), encoded by the polynucleotide sequence according to SEQ ID NO:1 (Figures 1A-B), and/or encoded by the polynucleotide contained within the deposited clone,
 15 K+betaM4, has significant homology at the nucleotide and amino acid level to the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov27 protein (K+Hnov27; Genbank Accession No. gi| Y34125; SEQ ID NO:4), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi|
 20 Y34129; SEQ ID NO:5), the Drosophila CG10440 protein (CG10440; Genbank Accession No. gi|7291303; SEQ ID NO:6), and a human neuroblastoma protein (neuroblastoma; Genbank Accession No. gi|12654691; SEQ ID NO:5). An alignment of the K+betaM4 polypeptide with these proteins is provided in Figures 2A-B.

The K+betaM4 polypeptide was determined to share 26.1% identity and
 25 39.1% similarity with the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), to share 31.6% identity and 45.1% similarity with the human potassium channel K+Hnov27 protein (K+Hnov27; Genbank Accession No. gi| Y34125; SEQ ID NO:4), to share 42.3% identity and 50.5% similarity with the human potassium channel K+Hnov28 protein (K+Hnov28;
 30 Genbank Accession No. gi| Y34129; SEQ ID NO:5), to share 36.2% identity and 47.3% similarity with the Drosophila CG10440 protein (CG10440; Genbank Accession No. gi|7291303; SEQ ID NO:6), and to share 28.0% identity and 38.6% similarity with the human neuroblastoma protein (neuroblastoma; Genbank Accession No. gi|12654691; SEQ ID NO:5) as shown in Figure 4.

35 The human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98) protein beta subunits increase the

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5 apparent Ca^{2+} sensitivity of the human MaxiK channel alpha subunit, as discussed elsewhere herein (Genomics 55 (1), 57-67 (1999); Proc. Natl. Acad. Sci. U.S.A. 93 (17), 9200-9205 (1996); FEBS Lett. 382 (1-2), 84-88 (1996); and J. Biol. Chem.... 269 (25), 17274-17278 (1994); which are hereby incorporated herein by reference in their entirety).

10 K+betaM4 polypeptides and polynucleotides are useful for diagnosing diseases related to the over and/or under expression of K+betaM4 by identifying mutations in the K+betaM4 gene using K+betaM4 sequences as probes or by determining K+betaM4 protein or mRNA expression levels. K+betaM4 polypeptides will be useful in screens for compounds that affect the activity of the protein.

15 K+betaM4 peptides can also be used for the generation of specific antibodies and as bait in yeast two hybrid screens to find proteins the specifically interact with K+betaM4. Based on the expression pattern of this novel sequence, diseases that can be treated with agonists and/or antagonists for K+betaM4 including, but not limited to, epilepsy, Bartter's syndrome, persistent hyperinsulinemic hypoglycemia of

20 infancy, hyperkalemia and hypokalemia, cystic fibrosis and hypercalciuric nephrolithiasis.

 Expression profiling designed to measure the steady state mRNA levels encoding the K+betaM4 polypeptide showed predominately high expression levels in liver and spinal cord; significantly in small intestine testis, and stomach, and to a

25 lesser extent, in heart, lymph node, uterus, kidney, and prostate (as shown in Figure 3).

 Expanded analysis of K+betaM4 expression levels by TaqMan™ quantitative PCR (see Figure 5) confirms and extends the earlier results obtained with SYBR green (Figure 4). As shown, K+betaM4 was expressed at low levels in most tissues

30 tested with predominate expression in brain, testis, and adrenal gland, and to a lesser extent in other tissues as shown.

 Based upon the observed homology, the polypeptide of the present invention may share at least some biological activity with potassium channel subunits, specifically with potassium channel beta subunits, more specifically with potassium

35 channel beta subunits containing at least one transmembrane domain, preferably with the potassium channel beta subunits referenced elsewhere herein.

5 As described elsewhere herein, potassium channel beta subunits have been implicated in modulating the activity of potassium channels. Such inhibition typically is manifested by potassium channel beta subunits binding to calcium ions and interacting with the cytoplasmic tail of potassium channel alpha subunits. Some potassium channel beta subunits inhibit potassium channel activity, while other beta
10 subunits have been shown to increase potassium channel activity (e.g., binding of KCNE3 to the KCNQ1 alpha subunit potassium channel leads to a constitutively opened channel). Depending upon whether the beta subunit enhances or inhibits potassium channel activity, determines whether a particular beta subunit can be referred to as a potassium channel agonist or antagonist.

15 Potassium channel antagonists are useful for a number of physiological disorders in mammals, including humans. Ion channels, including potassium channels, are found in all mammalian cells and are involved in the modulation of various physiological processes and normal cellular homeostasis. Potassium channels generally control the resting membrane potential, and the efflux of potassium ions
20 causes repolarization of the plasma membrane after cell depolarization. Potassium channel antagonists prevent repolarization and cause the cell to stay in the depolarized, excited state.

There are a number of potassium channel subtypes. Physiologically, one important subtype is the maxi-K channel, defined as high-conductance calcium-
25 activated potassium channel, which is present in neuronal tissue and smooth muscle. Intracellular calcium concentration ($Ca_{sub.2+}$) and membrane potential gate these channels. For example, maxi-K channels are opened to enable efflux of potassium ions by an increase in the intracellular $Ca_{sub.2+}$ concentration or by membrane depolarization (change in potential). Elevation of intracellular calcium
30 concentration is required for neurotransmitter release, smooth muscle contraction, proliferation of some cell types and other processes. Modulation of maxi-K channel activity therefore affects cellular processes that depend on influx of calcium through voltage-dependent pathways, such as transmitter release from the nerve terminals and smooth muscle contraction.

35 A number of marketed drugs function as potassium channel antagonists. The most important of these include the compounds Glyburide, Glipizide and

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5 Tolbutamide. These potassium channel antagonists are useful as antidiabetic agents. Potassium channel antagonists are also utilized as Class III antiarrhythmic agents and to treat acute infarctions in humans. A number of naturally occurring toxins are known to block potassium channels including apamin, iberiotoxin, charybdotoxin, margatoxin, noxiustoxin, kaliotoxin, dendrotoxin(s), mast cell degranulating (MCD)
10 peptide, and beta.-bungarotoxin .beta.-BTX). The K+betaM4 polypeptides may be used in in vitro and in vivo models to test the specificity of novel compounds, and of analogs and derivatives of compounds known to act on potassium channels.

Depression is related to a decrease in neurotransmitter release. Current treatments of depression include blockers of neurotransmitter uptake, and inhibitors of
15 enzymes involved in neurotransmitter degradation which act to prolong the lifetime of neurotransmitters.

It is believed that certain diseases such as depression, memory disorders and Alzheimer's disease are the result of an impairment in neurotransmitter release.

Potassium channel antagonists may therefore be utilized as cell excitants
20 which may stimulate release of neurotransmitters such as acetylcholine, serotonin and dopamine. Enhanced neurotransmitter release may reverse the symptoms associated with depression and Alzheimer's disease.

The K+betaM4 polynucleotides and polypeptides of the present invention, including agonists and/or fragments thereof, have uses that include modulating
25 potassium channel activity in various cells, tissues, and organisms, and particularly in mammalian liver, spinal cord, small intestine, testis, stomach, heart, lymph node, uterus, kidney, and prostate, preferably human. K+betaM4 polynucleotides and polypeptides of the present invention, including agonists and/or fragments thereof, may be useful in diagnosing, treating, prognosing, and/or preventing hepatic, neural,
30 gastrointestinal, reproductive, cardiovascular, immune, and/or renal diseases or disorders.

The strong homology to human potassium channel beta subunit proteins, combined with the predominately high expression in liver suggests the K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing,
35 and/or preventing liver disorders and cancers. Representative uses are described in the "Hyperproliferative Disorders", "Infectious Disease", and "Binding Activity" sections

5 below, and elsewhere herein. Briefly, the protein can be used for the detection, treatment, and/or prevention of hepatoblastoma, jaundice, hepatitis, liver metabolic diseases and conditions that are attributable to the differentiation of hepatocyte progenitor cells, cirrhosis, hepatic cysts, pyrogenic abscess, amebic abscess, hydatid cyst, cystadenocarcinoma, adenoma, focal nodular hyperplasia, hemangioma, 10 hepatocellular carcinoma, cholangiocarcinoma, angiosarcoma, and granulomatous liver disease. In addition the expression in fetus would suggest a useful role for the protein product in developmental abnormalities, fetal deficiencies, pre-natal disorders and various would-healing diseases and/or tissue trauma.

The identification of a novel potassium channel beta subunit with predominate 15 expression in liver is significant since a number of identified potassium channels have not shown detectable expression in liver (Stoffel, M., Tokuyama, Y., Trabb, JB., German, MS., Tsar, ML., LY., Polonsky, KS., Bell, GI, Biochem, Biophys, Res, Commun., 212(3):894-9, (1995); Sakura, H., Ammala, C., Smith, PA., Gribble, FM., Ashcroft, FM, Lett., 377(3):338-44, (1995); Jiang, Z., Wallner, M., Meera, P., Toro, 20 L, Genomics., 55(1):57-67, (1999); Zhu, XR., Wulf, A., Schwarz, M., Isbrandt, D., Pongs, O, Receptors, Channels. 199, 6(5):387-400, (1999)).

More importantly, recent studies have shown that KATP channels regulate mitogenically induced proliferation in primary rat hepatocytes and human liver cell lines (Malhi, H., Irani, AN., Rajvanshi, P., Suadicani, SO., Spray, DC., McDonald, 25 TV., Gupta, S, J. Biol, Chem., 275(34):26050-7, (2000)). Such a finding has profound implications for treating and/or ameliorating liver proliferation and cancers due to the potential for potassium channel beta subunits to modulate potassium channel function.

Thus, K+betaM4 polynucleotides and polypeptides, including fragments and agonists thereof, have uses which include treating, ameliorating, and/or preventing 30 proliferating liver disorders, including cancers.

Moreover, polynucleotides and polypeptides, including fragments and/or antagonists thereof, have uses which include, directly or indirectly, treating, preventing, diagnosing, and/or prognosing the following, non-limiting, hepatic infections: liver disease caused by sepsis infection, liver disease caused by 35 bacteremia, liver disease caused by Pneumococcal pneumonia infection, liver disease caused by Toxic shock syndrome, liver disease caused by Listeriosis, liver disease

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5 caused by Legionnaires' disease, liver disease caused by Brucellosis infection, liver
 disease caused by Neisseria gonorrhoeae infection, liver disease caused by Yersinia
 infection, liver disease caused by Salmonellosis, liver disease caused by Nocardiosis,
 liver disease caused by Spirochete infection, liver disease caused by Treponema
 pallidum infection, liver disease caused by Brrelia burgdorferi infection, liver disease
 10 caused by Leptospirosis, liver disease caused by Coxiella burnetii infection, liver
 disease caused by Rickettsia richettsii infection, liver disease caused by Chlamydia
 trachomatis infection, liver disease caused by Chlamydia psittaci infection, in addition
 to any other hepatic disease and/or disorder implicated by the causative agents listed
 above or elsewhere herein.

15 Alternatively, the strong homology to human potassium channel beta subunit
 proteins, combined with the predominately high expression in spinal cord suggests the
 K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing,
 prognosing, and/or preventing neurodegenerative disease states, behavioral disorders,
 or inflammatory conditions. Representative uses are described in the "Regeneration"
 20 and "Hyperproliferative Disorders" sections below, in the Examples, and elsewhere
 herein. Briefly, the uses include, but are not limited to the detection, treatment, and/or
 prevention of Alzheimer's Disease, Parkinson's Disease, Huntington's Disease,
 Tourette Syndrome, meningitis, encephalitis, demyelinating diseases, peripheral
 neuropathies, neoplasia, trauma, congenital malformations, spinal cord injuries,
 25 ischemia and infarction, aneurysms, hemorrhages, schizophrenia, mania, dementia,
 paranoia, obsessive compulsive disorder, depression, panic disorder, learning
 disabilities, ALS, psychoses, autism, and altered behaviors, including disorders in
 feeding, sleep patterns, balance, and perception. In addition, elevated expression of
 this gene product in regions of the brain indicates it plays a role in normal neural
 30 function. Potentially, this gene product is involved in synapse formation,
 neurotransmission, learning, cognition, homeostasis, or neuronal differentiation or
 survival. Furthermore, the protein may also be used to determine biological activity,
 to raise antibodies, as tissue markers, to isolate cognate ligands or receptors, to
 identify agents that modulate their interactions, in addition to its use as a nutritional
 35 supplement. Protein, as well as, antibodies directed against the protein may show
 utility as a tumor marker and/or immunotherapy targets for the above listed tissues.

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5 The strong homology to human potassium channel beta subunits, combined with the localized expression in small intestine and stomach suggests the K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing gastrointestinal diseases and/or disorders, which include, but are not limited to, ulcers, irritable bowel syndrome, inflammatory bowel disease, diarrhea, 10 traveler's diarrhea, drug-related diarrhea polyps, absorption disorders, constipation, diverticulitis, vascular disease of the intestines, intestinal obstruction, intestinal infections, ulcerative colitis, Shigellosis, cholera, Crohn's Disease, amebiasis, enteric fever, Whipple's Disease, peritonitis, intrabdominal abscesses, hereditary hemochromatosis, gastroenteritis, viral gastroenteritis, food poisoning, mesenteric ischemia, mesenteric infarction, in addition to, metabolic diseases and/or disorders. 15

 Moreover, K+betaM4 polynucleotides and polypeptides, including fragments and/or antagonists thereof, have uses which include, directly or indirectly, treating, preventing, diagnosing, and/or prognosing susceptibility to the following, non-limiting, gastrointestinal infections: Salmonella infection, E.coli infection, E.coli 20 O157:H7 infection, Shiga Toxin-producing E.coli infection, Campylobacter infection (e.g., Campylobacter fetus, Campylobacter upsaliensis, Campylobacter hyointestinalis, Campylobacter lari, Campylobacter jejuni, Campylobacter concisus, Campylobacter mucosalis, Campylobacter sputorum, Campylobacter rectus, Campylobacter curvus, Campylobacter sputorum, etc.), Heliobacter infection (e.g., 25 Heliobacter cinaedi, Heliobacter fennelliae, etc.) Yersinia enterocolitica infection, Vibrio sp. Infection (e.g., Vibrio mimicus, Vibrio parahaemolyticus, Vibrio fluvialis, Vibrio furnissii, Vibrio hollisae, Vibrio vulnificus, Vibrio alginolyticus, Vibrio metschnikovii, Vibrio damsela, Vibrio cincinnatiensis, etc.) Aeromonas infection (e.g., Aeromonas hydrophila, Aeromonas sobira, Aeromonas caviae, etc.), 30 Plesiomonas shigelliodes infection, Giardia infection (e.g., Giardia lamblia, etc.), Cryptosporidium infection, Listeria infection, Entamoeba histolytica infection, Rotavirus infection, Norwalk virus infection, Clostridium difficile infection, Clostridium perfringens infection, Staphylococcus infection, Bacillus infection, in addition to any other gastrointestinal disease and/or disorder implicated by the 35 causative agents listed above or elsewhere herein.

Alternatively, the strong homology to potassium channel beta subunits, combined with the localized expression in testis tissue emphasizes the potential utility for K+betaM4 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing testicular, in addition to reproductive disorders.

In preferred embodiments, K+betaM4 polynucleotides and polypeptides including agonists and fragments thereof, have uses which include treating, diagnosing, prognosing, and/or preventing the following, non-limiting, diseases or disorders of the testis: spermatogenesis, infertility, Klinefelter's syndrome, XX male, epididymitis, genital warts, germinal cell aplasia, cryptorchidism, varicocele, immotile cilia syndrome, and viral orchitis. The K+betaM4 polynucleotides and polypeptides including agonists and fragments thereof, may also have uses related to modulating testicular development, embryogenesis, reproduction, and in ameliorating, treating, and/or preventing testicular proliferative disorders (e.g., cancers, which include, for example, choriocarcinoma, Nonseminoma, seminoma, and testicular germ cell tumors).

Likewise, the localized expression in testis tissue also emphasizes the potential utility for K+betaM4 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing metabolic diseases and disorders which include the following, not limiting examples: premature puberty, incomplete puberty, Kallman syndrome, Cushing's syndrome, hyperprolactinemia, hemochromatosis, congenital adrenal hyperplasia, FSH deficiency, and granulomatous disease, for example.

This gene product may also be useful in assays designed to identify binding agents, as such agents (antagonists) are useful as male contraceptive agents. The testes are also a site of active gene expression of transcripts that is expressed, particularly at low levels, in other tissues of the body. Therefore, this gene product may be expressed in other specific tissues or organs where it may play related functional roles in other processes, such as hematopoiesis, inflammation, bone formation, and kidney function, to name a few possible target indications.

The strong homology to human potassium channel beta subunits, combined with the predominate localized expression in heart tissue suggests the K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing cardiovascular diseases and/or disorders, which include, but are not

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5 limited to: myocardio infarction, congestive heart failure, arrhythmias,
cardiomyopathy, atherosclerosis, arterialsclerosis, microvascular disease, embolism,
thromobosis, pulmonary edema, palpitation, dyspnea, angina, hypotension, syncope,
heart murmer, aberrant ECG, hypertrophic cardiomyopathy, the Marfan syndrome,
sudden death, prolonged QT syndrome, congenital defects, cardiac viral infections,
10 valvular heart disease, and hypertension.

Similarly, K+betaM4 polynucleotides and polypeptides may be useful for
ameliorating cardiovascular diseases and symptoms which result indirectly from
various non-cardiavascular effects, which include, but are not limited to, the
following, obesity, smoking, Down syndrome (associated with endocardial cushion
15 defect); bony abnormalities of the upper extremities (associated with atrial septal
defect in the Holt-Oram syndrome); muscular dystrophies (associated with
cardiomyopathy); hemochromatosis and glycogen storage disease (associated with
myocardial infiltration and restrictive cardiomyopathy); congenital deafness
(associated with prolonged QT interval and serious cardiac arrhythmias); Raynaud's
20 disease (associated with primary pulmonary hypertension and coronary vasospasm);
connective tissue disorders, i.e., the Marfan syndrome, Ehlers-Danlos and Hurler
syndromes, and related disorders of mucopolysaccharide metabolism (aortic
dilatation, prolapsed mitral valve, a variety of arterial abnormalities); acromegaly
(hypertension, accelerated coronary atherosclerosis, conduction defects,
25 cardiomyopathy); hyperthyroidism (heart failure, atrial fibrillation); hypothyroidism
(pericardial effusion, coronary artery disease); rheumatoid arthritis (pericarditis, aortic
valve disease); scleroderma (cor pulmonale, myocardial fibrosis, pericarditis);
systemic lupus erythematosus (valvulitis, myocarditis, pericarditis); sarcoidosis
(arrhythmias, cardiomyopathy); postmenopausal effects, Chlamydial infections,
30 polycystic ovary disease, thyroid disease, alcoholism, diet, and exfoliative dermatitis
(high-output heart failure), for example.

Moreover, polynucleotides and polypeptides, including fragments and/or
antagonists thereof, have uses which include, directly or indirectly, treating,
preventing, diagnosing, and/or prognosing the following, non-limiting, cardiovascular
35 infections: blood stream invasion, bacteremia, sepsis, Streptococcus pneumoniae
infection, group a streptococci infection, group b streptococci infection, Enterococcus

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- 5 infection, nonenterococcal group D streptococci infection, nonenterococcal group C streptococci infection, nonenterococcal group G streptococci infection, Streptococcus viridans infection, Staphylococcus aureus infection, coagulase-negative staphylococci infection, gram-negative Bacilli infection, Enterobacteriaceae infection, Psudomonas spp. Infection, Acinobacter spp. Infection, Flavobacterium meningosepticum
- 10 infection, Aeromonas spp. Infection, Stenotrophomonas maltophilia infection, gram-negative coccobacilli infection, Haemophilus influenza infection, Branhamella catarrhalis infection, anaerobe infection, Bacteriodes fragilis infection, Clostridium infection, fungal infection, Candida spp. Infection, non-albicans Candida spp. Infection, Hansenula anomala infection, Malassezia furfur infection, nontuberculous
- 15 Mycobacteria infection, Mycobacterium avium infection, Mycobacterium chelonae infection, Mycobacterium fortuitum infection, spirochetal infection, Borrelia burgdorferi infection, in addition to any other cardiovascular disease and/or disorder (e.g., non-sepsis) implicated by the causative agents listed above or elsewhere herein.

The strong homology to human potassium channel beta subunits, combined

20 with the localized expression in kidney tissue suggests the K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing renal diseases and/or disorders, which include, but are not limited to: nephritis, renal failure, nephrotic syndrome, urinary tract infection, hematuria, proteinuria, oliguria, polyuria, nocturia, edema, hypertension, electrolyte disorders, sterile pyuria, renal

25 osteodystrophy, large kidneys, renal transport defects, nephrolithiasis, azotemia, anuria, urinary retention ,slowing of urinary stream, large prostate, flank tenderness, full bladder sensation after voiding, enuresis, dysuria,bacteriuria, kideny stones, glomerulonephritis, vasculitis, hemolytic uremic syndromes, thrombotic thrombocytopenic purpura, malignant hypertension, casts, tubulointerstitial kidney

30 diseases, renal tubular acidosis, pyelonephritis, hydronephritis, nephrotic syndrome, crush syndrome, and/or renal colic, in addition to Wilm's Tumor Disease, and congenital kidney abnormalities such as horseshoe kidney, polycystic kidney, and Falconi's syndrome.for example.

The strong homology to human potassium channel beta subunits, combined

35 with the localized expression in lymph node tissue suggests the K+betaM4 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing,

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5 and/or preventing immune diseases and/or disorders. Representative uses are described in the "Immune Activity", "Chemotaxis", and "Infectious Disease" sections below, and elsewhere herein. Briefly, the strong expression in immune tissue indicates a role in regulating the proliferation; survival; differentiation; and/or activation of hematopoietic cell lineages, including blood stem cells.

10 The K+betaM4 polypeptide may also be useful as a preventative agent for immunological disorders including arthritis, asthma, immunodeficiency diseases such as AIDS, leukemia, rheumatoid arthritis, granulomatous disease, inflammatory bowel disease, sepsis, acne, neutropenia, neutrophilia, psoriasis, hypersensitivities, such as T-cell mediated cytotoxicity; immune reactions to transplanted organs and tissues,
15 such as host-versus-graft and graft-versus-host diseases, or autoimmunity disorders, such as autoimmune infertility, lense tissue injury, demyelination, systemic lupus erythematosus, drug induced hemolytic anemia, rheumatoid arthritis, Sjogren's disease, and scleroderma. Moreover, the protein may represent a secreted factor that influences the differentiation or behavior of other blood cells, or that recruits
20 hematopoietic cells to sites of injury. Thus, this gene product may be useful in the expansion of stem cells and committed progenitors of various blood lineages, and in the differentiation and/or proliferation of various cell types.

Moreover, the K+betaM4 polypeptide may be useful for modulating cytokine production, antigen presentation, or other processes, such as for boosting immune
25 responses, etc. Expression in cells of lymphoid origin, indicates the natural gene product would be involved in immune functions. Therefore it would also be useful as an agent for immunological disorders including arthritis, asthma, immunodeficiency diseases such as AIDS, leukemia, rheumatoid arthritis, granulomatous disease, inflammatory bowel disease, sepsis, acne, neutropenia, neutrophilia, psoriasis,
30 hypersensitivities, such as T-cell mediated cytotoxicity; immune reactions to transplanted organs and tissues, such as host-versus-graft and graft-versus-host diseases, or autoimmunity disorders, such as autoimmune infertility, lense tissue injury, demyelination, systemic lupus erythematosus, drug induced hemolytic anemia, rheumatoid arthritis, Sjogren's disease, and scleroderma.

35 Moreover, the protein may represent a secreted factor that influences the differentiation or behavior of other blood cells, or that recruits hematopoietic cells to

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5 sites of injury. Thus, this gene product is thought to be useful in the expansion of stem cells and committed progenitors of various blood lineages, and in the differentiation and/or proliferation of various cell types. Furthermore, the protein may also be used to determine biological activity, raise antibodies, as tissucemarkers, to isolate cognate ligands or receptors, to identify agents that modulate their interactions, in addition to
 10 its use as a nutritional supplement. Protein, as well as, antibodies directed against the protein may show utility as a tumor marker and/or immunotherapy targets for the above listed tissues.

The strong homology to potassium channel beta subunits, combined with the localized expression in uterus tissue emphasizes the potential utility for K+betaM4
 15 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing uterine, in addition to reproductive disorders.

In preferred embodiments, K+betaM4 polynucleotides and polypeptides including agonists and fragments thereof, have uses which include treating, diagnosing, prognosing, and/or preventing the following, non-limiting, diseases or
 20 disorders of the uterus: dysfunctional uterine bleeding, amenorrhea, primary dysmenorrhea, sexual dysfunction, infertility, pelvic inflammatory disease, endometriosis, placental aromatase deficiency, premature menopause, and placental dysfunction.

The K+betaM4 polynucleotides and polypeptides also have uses which
 25 include, but are not limited to treating, diagnosing, prognosing, and/or preventing proliferative disorders which include the following non-limiting examples: carcinoid tumor, islet cell carcinoma, Zollinger-Ellison gastrinoma, insulinoma, vipoma, glucagonoma, somatostatinoma, grfoma, crfoma, ppoma, neurotensinoma, and small cell carcinoma.

30 In addition, antagonists of the K+betaM4 polynucleotides and polypeptides may have uses that include diagnosing, treating, prognosing, and/or preventing diseases or disorders related to hyper potassium channel beta subunit activity, which may include immune, hematopoietic, metabolic, gastrointestinal, renal, neural, and/or proliferative diseases or disorders.

35 Alternatively, K+betaM4 polypeptides of the invention, or agonists thereof, are administered to treat, prevent, prognose, and/or diagnose disorders involving

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5 excessive smooth muscle tone or excitability, which include, but are not limited to asthma, angina, hypertension, incontinence, pre-term labor, and irritable bowel syndrome.

The potential involvement of aberrant potassium channel beta subunits in intestinal disease has been noted due to the colocalization of the potassium channel
10 alpha subunit KNCQ1 with the potassium channel beta subunit KCNE3, and the ability of KCNE3 to significantly modulate KNCQ1 function (Schroeder, BC., Waldegger, S., Fehr, S., Bleich, M., Warth, R., Greger, R., Jentsch, TJ. Nature. 1, 403(6766):196-9, (2000)). It is believed that KCNE3 modulated cyclic AMP-stimulated intestinal chloride secretion and is involved in secretory diarrhoea and
15 cystic fibrosis.

Thus, K+betaM4 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include modulating cycline AMP stimulated intestinal chloride secretion, and ameliorating, treating, and/or preventing diarrhea and cystic fibrosis.

20 Recently, two large-conductance calcium-activated potassium (BK) channel beta subunits were identified hKCNMB3 and hKCNMB4 and characterized (Behrens, R., Nolting, A., Reimann, F., Schwarz, M., Waldschutz, R., Pongs, O, Lett., 474(1):99-106, (2000)). These beta subunits were shown to significantly slow activation kinetics, led to a steeper apparent calcium sensitivity, and shifted the
25 voltage range of BK current activation to more negative potentials of potassium channel upon coexpression. In addition, the resulting alpha/beta channels were not blocked by 100 nM charybdotoxin or iberiotoxin, and were activated by 17beta-estradiol.

Thus, K+betaM4 polynucleotides and polypeptides, including fragments and
30 agonists thereof, may have uses which include slowing activation kinetics of potassium channels, increasing calcium sensitivity of potassium channels, and/or shifting the voltage range of potassium channel current activation to more negative potentials.

The present invention encompasses compositions comprising pharmaceutical
35 effective amounts of the K+betaM4 polypeptide, and optionally further comprising

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5 effective amounts of 17beta-estradiol suitable for sufficiently activating the administered K+betaM4 polypeptides.

Potassium channel beta subunits have also been shown to activate the ability of potassium channel alpha subunits to inhibit potassium channel membrane excitability and neuron activation in brain (Wissmann, R., Baukrowitz, T., Kalbacher, H., Kalbitzer, HR., Ruppersberg, JP., Pongs, O., Antz, C., Fakler, B, J. Biol, Chem.,
 10 274(50):35521-5, (1999)). Additional potassium channel beta subunits have also been shown in accelerate certain alpha subunits ability to inactivate delayed rectifier channels, specifically Kv1.1 and Kv1.4 delta 1-110 (Heinemann, SH., Rettig, J., Graack, HR., Pongs, O, J. Physiol, Lond., 493 (Pt 3):625-33, (1996)).

15 Thus, K+betaM4 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include accelerating potassium channel alpha subunits ability to inhibit and/or inactivate potassium channels, in addition to, activate potassium channel alpha subunits ability to inactivate and/or inhibit potassium channels (Heinemann, SH., Rettig, J., Wunder, F., Pongs, O, Lett., 377(3):383-9,
 20 (1995)).

Moreover, K+betaM4 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include treating, diagnosing, prognosing, and/or preventing some classes of disorders that may be affected by effective manipulation of Shaker-like potassium ion channels, either directly or indirectly,
 25 which include neurological disorders, tumor driven diseases, metabolic diseases, cardiac diseases, and autoimmune diseases. Examples of disease states and conditions from these and other classes, as well as affected normal body functions, encompass: hypoglycemia, anoxia/hypoxia, renal disease, osteoporosis, hyperkalemia, hypokalemia, hypertension, Addison's disease, abnormal apoptosis, induced
 30 apoptosis, clotting, modulation of acetylcholine function, and modulation of monoaminesepilepsy, allergic encephalomyelitis, multiple sclerosis (any demylelinating disease), acute traverse myelitis, neurofibromatosis, cardioplegia, cardiomyopathy, ischemia, ischemia reperfusion, cerebral ischemia, sickle cell anemia, cardiac arrythmias, peripheral monocuropathy, polynucuropathy, Gullain-
 35 Barre' Syndrome, peroneal muscular dystrophy, neuropathies, Parkinson's disease, palsies, cerebral palsy, progressive supranuclear palsy, pseudobubar palsy,

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5 Huntington's disease, dystonia, dyskinesias, chorea, althetosis, choreothetosis, tics,
 memory degeneration, taste perception, smooth muscle function, skeletal muscle
 function, sleep disorders, modulation of neurotransmitters, acute disseminated
 encephalomyelitis, optic neuromyelitis, muscular dystrophy, myasthenia gravis,
 10 congestive heart failure, ischemia related disorders, cardiac dysrhythmias, diabetes,
 carcinomas, neurocarcinomas, autoimmune-hypertrophy, neuromyotonia (Isaac's
 Syndrome) muscular disorders associated with drug abuse, and treatment for
 poisoning.

K+betaM4 polypeptides and polynucleotides have additional uses which
 15 include diagnosing diseases related to the over and/or under expression of K+betaM4
 by identifying mutations in the K+betaM4 gene by using K+betaM4 sequences as
 probes or by determining K+betaM4 protein or mRNA expression levels. K+betaM4
 polypeptides may be useful for screening compounds that affect the activity of the
 protein. K+betaM4 peptides can also be used for the generation of specific antibodies
 20 and as bait in yeast two hybrid screens to find proteins the specifically interact with
 K+betaM4 (described elsewhere herein). Based on the expression pattern of this novel
 sequence, diseases that can be treated with agonists and/or antagonists for K+betaM4
 include various forms of generalized epilepsy.

Although it is believed the encoded polypeptide may share at least some
 25 biological activities with potassium channel beta subunits, a number of methods of
 determining the exact biological function of this clone are either known in the art or
 are described elsewhere herein. Briefly, the function of this clone may be determined
 by applying microarray methodology. Nucleic acids corresponding to the K+betaM4
 polynucleotides, in addition to, other clones of the present invention, may be arrayed
 30 on microchips for expression profiling. Depending on which polynucleotide probe is
 used to hybridize to the slides, a change in expression of a specific gene may provide
 additional insight into the function of this gene based upon the conditions being
 studied. For example, an observed increase or decrease in expression levels when the
 polynucleotide probe used comes from tissue that has been treated with known
 35 potassium channel inhibitors, which include, but are not limited to the drugs listed
 above, might indicate a function in modulating potassium channel function, for

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5 example. In the case of K+betaM4, liver, spinal cord, small intestine, testis, stomach, heart, lymph node, uterus, kidney, and prostate tissue should be used to extract RNA to prepare the probe.

In addition, the function of the protein may be assessed by applying quantitative PCR methodology, for example. Real time quantitative PCR would provide the capability of following the expression of the K+betaM4 gene throughout development, for example. Quantitative PCR methodology requires only a nominal amount of tissue from each developmentally important step is needed to perform such experiments. Therefore, the application of quantitative PCR methodology to refining the biological function of this polypeptide is encompassed by the present invention.

10 Also encompassed by the present invention are quantitative PCR probes corresponding to the polynucleotide sequence provided as SEQ ID NO:1 (Figures 1A-B).

The function of the protein may also be assessed through complementation assays in yeast. For example, in the case of the K+betaM4, transforming yeast deficient in potassium channel beta subunit activity and assessing their ability to grow would provide convincing evidence the K+betaM4 polypeptide has potassium channel beta subunit activity. Additional assay conditions and methods that may be used in assessing the function of the polynucleotides and polypeptides of the present invention are known in the art, some of which are disclosed elsewhere herein.

20

Alternatively, the biological function of the encoded polypeptide may be determined by disrupting a homologue of this polypeptide in Mice and/or rats and observing the resulting phenotype.

25

Moreover, the biological function of this polypeptide may be determined by the application of antisense and/or sense methodology and the resulting generation of transgenic mice and/or rats. Expressing a particular gene in either sense or antisense orientation in a transgenic mouse or rat could lead to respectively higher or lower expression levels of that particular gene. Altering the endogenous expression levels of a gene can lead to the observation of a particular phenotype that can then be used to derive indications on the function of the gene. The gene can be either over-expressed or under expressed in every cell of the organism at all times using a strong ubiquitous promoter, or it could be expressed in one or more discrete parts of the organism using a

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5 well characterized tissue-specific promoter (e.g., a liver, spinal cord, small intestine, testis, stomach, heart, lymph node, uterus, kidney, and prostate-specific promoter), or it can be expressed at a specified time of development using an inducible and/or a developmentally regulated promoter.

In the case of K+betaM4 transgenic mice or rats, if no phenotype is apparent
10 in normal growth conditions, observing the organism under diseased conditions (hepatic, neural, gastrointestinal, reproductive, cardiovascular, immune, renal, or proliferative disorders, etc.) may lead to understanding the function of the gene. Therefore, the application of antisense and/or sense methodology to the creation of transgenic mice or rats to refine the biological function of the polypeptide is
15 encompassed by the present invention.

In preferred embodiments, the following N-terminal K+betaM4 deletion polypeptides are encompassed by the present invention: M1-R351, T2-R351, G3-R351, S4-R351, H5-R351, D6-R351, V7-R351, I8-R351, G9-R351, G10-R351, A11-R351, G12-R351, K13-R351, Q14-R351, V15-R351, L16-R351, C17-R351, C18-R351, F19-R351, C20-R351, K21-R351, Q22-R351, R23-R351, N24-R351, K25-R351, S26-R351, L27-R351, G28-R351, T29-R351, Y30-R351, P31-R351, G32-R351, V33-R351, P34-R351, G35-R351, N36-R351, A37-R351, L38-R351, W39-R351, L40-R351, L41-R351, T42-R351, S43-R351, P44-R351, A45-R351, C46-R351, N47-R351, A48-R351, L49-R351, S50-R351, T51-R351, S52-R351, A53-R351, V54-R351, M55-R351, H56-R351, G57-R351, R58-R351, D59-R351, K60-R351, G61-R351, S62-R351, V63-R351, T64-R351, H65-R351, G66-R351, T67-R351, V68-R351, Q69-R351, V70-R351, L71-R351, S72-R351, D73-R351, T74-R351, R75-R351, F76-R351, F77-R351, S78-R351, C79-R351, R80-R351, E81-R351, G82-R351, L83-R351, L84-R351, P85-R351, A86-R351, T87-R351, Q88-R351, S89-R351, P90-R351, A91-R351, M92-R351, S93-R351, D94-R351, P95-R351, I96-R351, T97-R351, L98-R351, N99-R351, V100-R351, G101-R351, G102-R351, K103-R351, L104-R351, Y105-R351, T106-R351, T107-R351, S108-R351, L109-R351, A110-R351, T111-R351, L112-R351, T113-R351, S114-R351, F115-R351, P116-R351, D117-R351, S118-R351, M119-R351, L120-R351, G121-R351, A122-R351, M123-R351, F124-R351, S125-R351, G126-R351, K127-R351, M128-R351, P129-R351, T130-R351, K131-R351, R132-R351, D133-R351, S134-R351,

[illegible]

Q135-R351, G136-R351, N137-R351, C138-R351, F139-R351, I140-R351, D141-R351, R142-R351, D143-R351, G144-R351, K145-R351, V146-R351, F147-R351, R148-R351, Y149-R351, I150-R351, L151-R351, N152-R351, F153-R351, L154-R351, R155-R351, T156-R351, S157-R351, H158-R351, L159-R351, D160-R351, L161-R351, P162-R351, E163-R351, D164-R351, F165-R351, Q166-R351, E167-R351, M168-R351, G169-R351, L170-R351, L171-R351, R172-R351, R173-R351, E174-R351, A175-R351, D176-R351, F177-R351, Y178-R351, Q179-R351, V180-R351, Q181-R351, P182-R351, L183-R351, I184-R351, E185-R351, A186-R351, L187-R351, Q188-R351, E189-R351, K190-R351, E191-R351, V192-R351, E193-R351, L194-R351, S195-R351, K196-R351, A197-R351, E198-R351, K199-R351, N200-R351, A201-R351, M202-R351, L203-R351, N204-R351, I205-R351, T206-R351, L207-R351, N208-R351, Q209-R351, R210-R351, V211-R351, Q212-R351, T213-R351, V214-R351, H215-R351, F216-R351, T217-R351, V218-R351, R219-R351, E220-R351, A221-R351, P222-R351, Q223-R351, I224-R351, Y225-R351, S226-R351, L227-R351, S228-R351, S229-R351, S230-R351, S231-R351, M232-R351, E233-R351, V234-R351, F235-R351, N236-R351, A237-R351, N238-R351, I239-R351, F240-R351, S241-R351, T242-R351, S243-R351, C244-R351, L245-R351, F246-R351, L247-R351, K248-R351, L249-R351, L250-R351, G251-R351, S252-R351, K253-R351, L254-R351, F255-R351, Y256-R351, C257-R351, S258-R351, N259-R351, G260-R351, N261-R351, L262-R351, S263-R351, S264-R351, I265-R351, T266-R351, S267-R351, H268-R351, L269-R351, Q270-R351, D271-R351, P272-R351, N273-R351, H274-R351, L275-R351, T276-R351, L277-R351, D278-R351, W279-R351, V280-R351, A281-R351, N282-R351, V283-R351, E284-R351, G285-R351, L286-R351, P287-R351, E288-R351, E289-R351, E290-R351, Y291-R351, T292-R351, K293-R351, Q294-R351, N295-R351, L296-R351, K297-R351, R298-R351, L299-R351, W300-R351, V301-R351, V302-R351, P303-R351, A304-R351, N305-R351, K306-R351, Q307-R351, I308-R351, N309-R351, S310-R351, F311-R351, Q312-R351, V313-R351, F314-R351, V315-R351, E316-R351, E317-R351, V318-R351, L319-R351, K320-R351, I321-R351, A322-R351, L323-R351, S324-R351, D325-R351, G326-R351, F327-R351, C328-R351, I329-R351, D330-R351, S331-R351, S332-R351, H333-R351, P334-R351, H335-R351, A336-R351, L337-R351, D338-R351, F339-R351, M340-R351, N341-R351, N342-R351,

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5 K343-R351, I344-R351, and/or I345-R351 of SEQ ID NO:2. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these N-terminal K+betaM4 deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

In preferred embodiments, the following C-terminal K+betaM4 deletion
 10 polypeptides are encompassed by the present invention: M1-R351, M1-Y350, M1-R349, M1-I348, M1-L347, M1-R346, M1-I345, M1-I344, M1-K343, M1-N342, M1-N341, M1-M340, M1-F339, M1-D338, M1-L337, M1-A336, M1-H335, M1-P334, M1-H333, M1-S332, M1-S331, M1-D330, M1-I329, M1-C328, M1-F327, M1-G326, M1-D325, M1-S324, M1-L323, M1-A322, M1-I321, M1-K320, M1-L319, M1-V318,
 15 M1-E317, M1-E316, M1-V315, M1-F314, M1-V313, M1-Q312, M1-F311, M1-S310, M1-N309, M1-I308, M1-Q307, M1-K306, M1-N305, M1-A304, M1-P303, M1-V302, M1-V301, M1-W300, M1-L299, M1-R298, M1-K297, M1-L296, M1-N295, M1-Q294, M1-K293, M1-T292, M1-Y291, M1-E290, M1-E289, M1-E288, M1-P287, M1-L286, M1-G285, M1-E284, M1-V283, M1-N282, M1-A281, M1-V280,
 20 M1-W279, M1-D278, M1-L277, M1-T276, M1-L275, M1-H274, M1-N273, M1-P272, M1-D271, M1-Q270, M1-L269, M1-H268, M1-S267, M1-T266, M1-I265, M1-S264, M1-S263, M1-L262, M1-N261, M1-G260, M1-N259, M1-S258, M1-C257, M1-Y256, M1-F255, M1-L254, M1-K253, M1-S252, M1-G251, M1-L250, M1-L249, M1-K248, M1-L247, M1-F246, M1-L245, M1-C244, M1-S243, M1-T242,
 25 M1-S241, M1-F240, M1-I239, M1-N238, M1-A237, M1-N236, M1-F235, M1-V234, M1-E233, M1-M232, M1-S231, M1-S230, M1-S229, M1-S228, M1-L227, M1-S226, M1-Y225, M1-I224, M1-Q223, M1-P222, M1-A221, M1-E220, M1-R219, M1-V218, M1-T217, M1-F216, M1-H215, M1-V214, M1-T213, M1-Q212, M1-V211, M1-R210, M1-Q209, M1-N208, M1-L207, M1-T206, M1-I205, M1-N204, M1-L203,
 30 M1-M202, M1-A201, M1-N200, M1-K199, M1-E198, M1-A197, M1-K196, M1-S195, M1-L194, M1-E193, M1-V192, M1-E191, M1-K190, M1-E189, M1-Q188, M1-L187, M1-A186, M1-E185, M1-I184, M1-L183, M1-P182, M1-Q181, M1-V180, M1-Q179, M1-Y178, M1-F177, M1-D176, M1-A175, M1-E174, M1-R173, M1-R172, M1-L171, M1-L170, M1-G169, M1-M168, M1-E167, M1-Q166, M1-F165,
 35 M1-D164, M1-E163, M1-P162, M1-L161, M1-D160, M1-L159, M1-H158, M1-S157, M1-T156, M1-R155, M1-L154, M1-F153, M1-N152, M1-L151, M1-I150, M1-

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5 Y149, M1-R148, M1-F147, M1-V146, M1-K145, M1-G144, M1-D143, M1-R142,
 M1-D141, M1-I140, M1-F139, M1-C138, M1-N137, M1-G136, M1-Q135, M1-S134,
 M1-D133, M1-R132, M1-K131, M1-T130, M1-P129, M1-M128, M1-K127, M1-
 G126, M1-S125, M1-F124, M1-M123, M1-A122, M1-G121, M1-L120, M1-M119,
 M1-S118, M1-D117, M1-P116, M1-F115, M1-S114, M1-T113, M1-L112, M1-T111,
 10 M1-A110, M1-L109, M1-S108, M1-T107, M1-T106, M1-Y105, M1-L104, M1-
 K103, M1-G102, M1-G101, M1-V100, M1-N99, M1-L98, M1-T97, M1-I96, M1-
 P95, M1-D94, M1-S93, M1-M92, M1-A91, M1-P90, M1-S89, M1-Q88, M1-T87,
 M1-A86, M1-P85, M1-L84, M1-L83, M1-G82, M1-E81, M1-R80, M1-C79, M1-S78,
 M1-F77, M1-F76, M1-R75, M1-T74, M1-D73, M1-S72, M1-L71, M1-V70, M1-Q69,
 15 M1-V68, M1-T67, M1-G66, M1-H65, M1-T64, M1-V63, M1-S62, M1-G61, M1-
 K60, M1-D59, M1-R58, M1-G57, M1-H56, M1-M55, M1-V54, M1-A53, M1-S52,
 M1-T51, M1-S50, M1-L49, M1-A48, M1-N47, M1-C46, M1-A45, M1-P44, M1-S43,
 M1-T42, M1-L41, M1-L40, M1-W39, M1-L38, M1-A37, M1-N36, M1-G35, M1-
 P34, M1-V33, M1-G32, M1-P31, M1-Y30, M1-T29, M1-G28, M1-L27, M1-S26,
 20 M1-K25, M1-N24, M1-R23, M1-Q22, M1-K21, M1-C20, M1-F19, M1-C18, M1-
 C17, M1-L16, M1-V15, M1-Q14, M1-K13, M1-G12, M1-A11, M1-G10, M1-G9,
 M1-I8, and/or M1-V7 of SEQ ID NO:2. Polynucleotide sequences encoding these
 polypeptides are also provided. The present invention also encompasses the use of
 these C-terminal K+betaM4 deletion polypeptides as immunogenic and/or antigenic
 25 epitopes as described elsewhere herein.

Alternatively, preferred polypeptides of the present invention may comprise
 polypeptide sequences corresponding to, for example, internal regions of the
 K+betaM4 polypeptide (e.g., any combination of both N- and C- terminal K+betaM4
 polypeptide deletions) of SEQ ID NO:2. For example, internal regions could be
 30 defined by the equation: amino acid NX to amino acid CX, wherein NX refers to any
 N-terminal deletion polypeptide amino acid of K+betaM4 (SEQ ID NO:2), and where
 CX refers to any C-terminal deletion polypeptide amino acid of K+betaM4 (SEQ ID
 NO:2). Polynucleotides encoding these polypeptides are also provided. The present
 invention also encompasses the use of these polypeptides as an immunogenic and/or
 35 antigenic epitope as described elsewhere herein.

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5 The K+betaM4 polypeptide of the present invention was determined to comprise two transmembrane domains located from about amino acid 27 to about amino acid 53, and/or from about amino acid 234 to about amino acid 258 of SEQ ID NO:2 (Figures 1A-B). In this context, the term “about” should be construed to mean 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 more amino
10 acids in either the N- or C-terminal direction of the above referenced polypeptides. Polynucleotides encoding these polypeptides are also provided.

 Preferred polypeptides of the invention comprise the following amino acid sequence: GTPGVPGNALWLLTSPACNALSTSA (SEQ ID NO:20), and/or VFNANIFSTSCFLKLLGSKLFYCS (SEQ ID NO:21). Polynucleotides encoding
15 these polypeptides are also provided. The present invention also encompasses the use of this K+betaM4 tetramerisation domain polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

 In preferred embodiments, the following N-terminal K+betaM4 TM1 transmembrane domain deletion polypeptides are encompassed by the present
20 invention: G1-A26, T2-A26, Y3-A26, P4-A26, G5-A26, V6-A26, P7-A26, G8-A26, N9-A26, A10-A26, L11-A26, W12-A26, L13-A26, L14-A26, T15-A26, S16-A26, P17-A26, A18-A26, C19-A26, and/or N20-A26 of SEQ ID NO:20. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these N-terminal K+betaM4 TM1 transmembrane domain
25 deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

 In preferred embodiments, the following C-terminal K+betaM4 TM1 transmembrane domain deletion polypeptides are encompassed by the present
invention: G1-A26, G1-S25, G1-T24, G1-S23, G1-L22, G1-A21, G1-N20, G1-C19,
30 G1-A18, G1-P17, G1-S16, G1-T15, G1-L14, G1-L13, G1-W12, G1-L11, G1-A10, G1-N9, G1-G8, and/or G1-P7 of SEQ ID NO:20. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these C-terminal K+betaM4 TM1 transmembrane domain deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

35 In preferred embodiments, the following N-terminal K+betaM4 TM2 transmembrane domain deletion polypeptides are encompassed by the present

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5 invention: V1-S25, F2-S25, N3-S25, A4-S25, N5-S25, I6-S25, F7-S25, S8-S25, T9-S25, S10-S25, C11-S25, L12-S25, F13-S25, L14-S25, K15-S25, L16-S25, L17-S25, G18-S25, and/or S19-S25 of SEQ ID NO:21. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these N-terminal K+betaM4 TM2 transmembrane domain deletion polypeptides as
10 immunogenic and/or antigenic epitopes as described elsewhere herein.

In preferred embodiments, the following C-terminal K+betaM4 TM2 transmembrane domain deletion polypeptides are encompassed by the present invention: V1-S25, V1-C24, V1-Y23, V1-F22, V1-L21, V1-K20, V1-S19, V1-G18, V1-L17, V1-L16, V1-K15, V1-L14, V1-F13, V1-L12, V1-C11, V1-S10, V1-T9, V1-
15 S8, and/or V1-F7 of SEQ ID NO:21. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these C-terminal K+betaM4 TM2 transmembrane domain deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

The K+betaM4 polypeptide of the present invention was determined to
20 comprise a K+ channel tetramerisation domain from about amino acid 94 to about amino acid 192 of SEQ ID NO:2 (Figures 1A-B) according to the Pfam domain analysis algorithm (Bateman, A., Birney, E. R., Durbin, S. R., Eddy, S. R., Howe, K. L., and Sonnhammer, E. L. L., Nucleic Acids Research 28, 263-266 (2000)). In this context, the term “about” should be construed to mean 1, 2, 3, 4, 5, 6,
25 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 more amino acids in either the N- or C-terminal direction of the above referenced polypeptide. Polynucleotides encoding these polypeptides are also provided.

The N-terminal, cytoplasmic tetramerization domain (T1) of voltage-gated K+ channels encodes molecular determinants for subfamily-specific assembly of alpha-subunits into functional tetrameric channels (Bixby et al., 1999). It is distantly related
30 to the BTB/POZ domain BTB. The presence of such a domain within a potassium channel beta-subunit may be required for associating with potassium channel alpha subunits and potassium channels. Such a domain may also be required for the beta – subunits ability to modulate potassium channel function.

35 Preferred polypeptides of the invention comprise the following amino acid

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5 sequence:

DPITLNVGGKLYTTSLATLTSFPDSMLGAMFSGKMPTKRDSQGNCFIDRDGK
VFRYILNFLRTSHLDLPEDFQEMGLLRREADFYQVQPLIEALQEKEV (SEQ ID
NO:12). Polynucleotides encoding these polypeptides are also provided. The present
invention also encompasses the use of this K+betaM4 tetramerisation domain
10 polypeptides as immunogenic and/or antigenic epitopes as described elsewhere
herein.

The K+betaM4 polypeptides of the present invention were determined to
comprise several phosphorylation sites based upon the Motif algorithm (Genetics
Computer Group, Inc.). The phosphorylation of such sites may regulate some
15 biological activity of the K+betaM4 polypeptide. For example, phosphorylation at
specific sites may be involved in regulating the proteins ability to associate or bind to
other molecules (e.g., proteins, ligands, substrates, DNA, etc.). In the present case,
phosphorylation may modulate the ability of the K+betaM4 polypeptide to associate
with other potassium channel alpha subunits, beta subunits, or its ability to modulate
20 potassium channel function.

The K+betaM4 polypeptide was predicted to comprise four PKC
phosphorylation sites using the Motif algorithm (Genetics Computer Group, Inc.). In
vivo, protein kinase C exhibits a preference for the phosphorylation of serine or
threonine residues. The PKC phosphorylation sites have the following consensus
25 pattern: [ST]-x-[RK], where S or T represents the site of phosphorylation and 'x' an
intervening amino acid residue. Additional information regarding PKC
phosphorylation sites can be found in Woodget J.R., Gould K.L., Hunter T., Eur. J.
Biochem. 161:177-184(1986), and Kishimoto A., Nishiyama K., Nakanishi H.,
Uratsuji Y., Nomura H., Takeyama Y., Nishizuka Y., J. Biol. Chem... 260:12492-
30 12499(1985); which are hereby incorporated by reference herein.

In preferred embodiments, the following PKC phosphorylation site
polypeptides are encompassed by the present invention: DTRFFSCREGLLP (SEQ ID
NO:16), LGAMFSGKMPTKR (SEQ ID NO:17), SGKMPTKRDSQGN (SEQ ID
NO:18), and/or QTVHFTVREAPQI (SEQ ID NO:19). Polynucleotides encoding
35 these polypeptides are also provided. The present invention also encompasses the use

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5 of these K+betaM4 PKC phosphorylation site polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

The K+betaM4 polypeptide has been shown to comprise three glycosylation sites according to the Motif algorithm (Genetics Computer Group, Inc.). As discussed more specifically herein, protein glycosylation is thought to serve a variety of
10 functions including: augmentation of protein folding, inhibition of protein aggregation, regulation of intracellular trafficking to organelles, increasing resistance to proteolysis, modulation of protein antigenicity, and mediation of intercellular adhesion.

Asparagine glycosylation sites have the following consensus pattern, N-{P}-
15 [ST]-{P}, wherein N represents the glycosylation site. However, it is well known that that potential N-glycosylation sites are specific to the consensus sequence Asn-Xaa-Ser/Thr. However, the presence of the consensus tripeptide is not sufficient to conclude that an asparagine residue is glycosylated, due to the fact that the folding of the protein plays an important role in the regulation of N-glycosylation. It has been
20 shown that the presence of proline between Asn and Ser/Thr will inhibit N-glycosylation; this has been confirmed by a recent statistical analysis of glycosylation sites, which also shows that about 50% of the sites that have a proline C-terminal to Ser/Thr are not glycosylated. Additional information relating to asparagine glycosylation may be found in reference to the following publications, which are
25 hereby incorporated by reference herein: Marshall R.D., Annu. Rev. Biochem. 41:673-702(1972); Pless D.D., Lennarz W.J., Proc. Natl. Acad. Sci. U.S.A. 74:134-138(1977); Bause E., Biochem. J. 209:331-336(1983); Gavel Y., von Heijne G., Protein Eng. 3:433-442(1990); and Miletich J.P., Broze G.J. Jr., J. Biol. Chem... 265:11397-11404(1990).

30 In preferred embodiments, the following asparagine glycosylation site polypeptide is encompassed by the present invention: FCKQRNKSLGTYPG (SEQ ID NO:13), KNAMLNITLNQRVQ (SEQ ID NO:14), and/or YCSNGNLSSITSHL (SEQ ID NO:15). Polynucleotides encoding these polypeptides are also provided. The present invention also encompasses the use of these K+betaM4 asparagine
35 glycosylation site polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

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5 The present invention also encompasses immunogenic and/or antigenic epitopes of the K+betaM4 polypeptide.

Many polynucleotide sequences, such as EST sequences, are publicly available and accessible through sequence databases. Some of these sequences are related to SEQ ID NO: 1 and may have been publicly available prior to conception of
10 the present invention. Preferably, such related polynucleotides are specifically excluded from the scope of the present invention. To list every related sequence would be cumbersome. Accordingly, preferably excluded from the present invention are one or more polynucleotides consisting of a nucleotide sequence described by the general formula of a-b, where a is any integer between 1 to 1825 of SEQ ID NO:1, b
15 is an integer between 15 to 1839, where both a and b correspond to the positions of nucleotide residues shown in SEQ ID NO:1, and where b is greater than or equal to a+14.

Features of the Polypeptide Encoded by Gene No:2

20 The polypeptide of this gene provided as SEQ ID NO:24 (Figures 6A-C), encoded by the polynucleotide sequence according to SEQ ID NO:23 (Figures 6A-C), and/or encoded by the polynucleotide contained within the deposited clone, K+betaM5, has significant homology at the nucleotide and amino acid level to the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No.
25 gi|4758625; SEQ ID NO:98), the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:3), the human lung protein (MGC:2376; Genbank Accession No. gi|12654469; SEQ ID NO:25), the human MSTP028 protein (MSTP028; Genbank Accession No. gi|11640564; SEQ ID NO:26); the Caenorhabditis K+ channel tetramerisation domain containing protein
30 (K+channel_tetra; Genbank Accession No. gi|3875362; SEQ ID NO:28); and the Drosophila CG10465 protein (CG10465; Genbank Accession No. gi|7302243; SEQ ID NO:27). An alignment of the K+betaM5 polypeptide with these proteins is provided in Figures 7A-B.

The K+betaM5 polypeptide was determined to share 20.0% identity and
35 40.0% similarity with the human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98), to share 31.7% identity and

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5 43.4% similarity with the human potassium channel K+Hnov28 protein (K+Hnov28; Genbank Accession No. gi| Y34129; SEQ ID NO:3), to share 34.4% identity and 45.6% similarity with the human lung protein, MGC:2376 (MGC:2376; Genbank Accession No. gi|12654469; SEQ ID NO:25), to share 31.7% identity and 43.4% similarity with the human MSTP028 protein (MSTP028; Genbank Accession No. gi|11640564; SEQ ID NO:26); to share 34.4% identity and 45.6% similarity with the Caenorhabditis K⁺ channel tetramerisation domain containing protein (K+channel_tetra; Genbank Accession No. gi|3875362; SEQ ID NO:28); and to share 30.8% identity and 38.3% similarity with the Drosophila CG10465 protein (CG10465; Genbank Accession No. gi|7302243; SEQ ID NO:27) as shown in Figure 15 4.

The human Maxi-K potassium channel beta subunit, KCNMB1 (Genbank Accession No. gi|4758625; SEQ ID NO:98) protein beta subunits increase the apparent Ca²⁺ sensitivity of the human MaxiK channel alpha subunit, as discussed elsewhere herein (Genomics 55 (1), 57-67 (1999); Proc. Natl. Acad. Sci. U.S.A. 93 (17), 9200-9205 (1996); FEBS Lett. 382 (1-2), 84-88 (1996); and J. Biol. Chem.... 20 (17), 9200-9205 (1996); FEBS Lett. 382 (1-2), 84-88 (1996); and J. Biol. Chem.... 269 (25), 17274-17278 (1994); which are hereby incorporated herein by reference in their entirety).

K+betaM5 polypeptides and polynucleotides are useful for diagnosing diseases related to the over and/or under expression of K+betaM5 by identifying mutations in the K+betaM5 gene using K+betaM5 sequences as probes or by determining K+betaM5 protein or mRNA expression levels. K+betaM5 polypeptides will be useful in screens for compounds that affect the activity of the protein. K+betaM5 peptides can also be used for the generation of specific antibodies and as bait in yeast two hybrid screens to find proteins the specifically interact with K+betaM5. Based on the expression pattern of this novel sequence, diseases that can be treated with agonists and/or antagonists for K+betaM5 including, but not limited to, epilepsy, Bartter's syndrome, persistent hyperinsulinemic hypoglycemia of infancy, hyperkalemia and hypokalemia, cystic fibrosis and hypercalciuric nephrolithiasis.

35 Expression profiling designed to measure the steady state mRNA levels encoding the K+betaM5 polypeptide showed predominately high expression levels in

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5 testis; significantly in spinal cord, lymph node, heart, uterus, and to a lesser extent, in small intestine, stomach, prostate, and kidney (as shown in Figure 8).

Expanded analysis of K+betaM5 expression levels by TaqMan™ quantitative PCR (see Figure 9) confirms and extends the earlier results obtained with SYBR green (Figure 8). As shown, K+betaM5 was expressed at low levels in with
10 predominate expression in testis.

Based upon the observed homology, the polypeptide of the present invention may share at least some biological activity with potassium channel subunits, specifically with potassium channel beta subunits, more specifically with potassium channel beta subunits containing at least one transmembrane domain, preferably with
15 the potassium channel beta subunits referenced elsewhere herein.

Additional experiments designed to identify and characterize the K+betaM5 homologue in Drosophila led to the identification of the CG10465 protein (Genbank Accession No. gi|17946205; SEQ ID NO:27) as representing the putative K+betaM5 Drosophila homologue, as described in Example 6. Characterization of the CG10465
20 protein suggested the physiological function of the CG10465 protein was to serve as a positive regulator in an innate immunity model in Drosophila cells with a similar profile as IkKB. RNAi experiments of positive regulators of this signaling pathway were found to have low luciferase activity as demonstrated with IkKB and Relish (Silverman et al., 2000). These results demonstrate that CG10465 regulates the LPS-
25 response pathway. Similarly, K+betaM5 is likely to have a similar role in mammalian immunity pathways.

The data showing that K+betaM5 plays a negative role in the NF-kB pathway, a pathway of key importance in innate immunity, suggests that agonists of this gene product could activate innate immunity. Innate immunity is the first line of defense
30 against microbial pathogens including bacteria, fungi, viruses, etc. The cells of the immune system which are responsible for innate immunity are primarily the macrophage/monocyte, and to a limited extent, neutrophils. Agonists of K+betaM5 could enhance the innate immune response and provide protection from invading pathogens in humans. In contrast, antagonists of K+betaM5 would be expected to
35 inhibit the NF-kB pathway and attenuate an inflammatory response. Hence, antagonists of K+betaM5 may be useful in the treatment of inflammatory diseases

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5 including rheumatoid arthritis, asthma, multiple sclerosis, osteoarthritis, among others. Thus, agonists of K+betaM5 may enhance an individuals immunity after vaccination. In contrast, antagonists of this K+betaM5 could be useful for treating T-cell mediated autoimmune diseases such as rheumatoid arthritis, multiple sclerosis, psoriasis, among others.

10 Alternatively, under certain circumstances, antagonists of K+betaM5 could activate innate immunity. Likewise, antagonists of K+betaM5 could enhance the innate immune response and provide protection from invading pathogens in humans. In contrast, agonists of K+betaM5 would be expected to inhibit the NF-kB pathway and attenuate an inflammatory response, Hence, agonists of K+betaM5 may be useful
15 in the treatment of inflammatory diseases including rheumatoid arthritis, asthma, multiple sclerosis, osteoarthritis, among others. K+betaM5 may also stimulate an immune response to tumors. In contrast, agonists of K+betaM5 could be useful for treating T-cell mediated autoimmune diseases such as rheumatoid arthritis, multiple sclerosis, psoriasis, among others.

20 As described elsewhere herein, potassium channel beta subunits have been implicated in modulating the activity of potassium channels. Such inhibition typically is manifested by potassium channel beta subunits binding to calcium ions and interacting with the cytoplasmic tail of potassium channel alpha subunits. Some potassium channel beta subunits inhibit potassium channel activity, while other beta
25 subunits have been shown to increase potassium channel activity (e.g., binding of KCNE3 to the KCNQ1 alpha subunit potassium channel leads to a constitutively opened channel). Depending upon whether the beta subunit enhances or inhibits potassium channel activity determines whether a particular beta subunit can be referred to as a potassium channel agonist or antagonist.

30 Potassium channel antagonists are useful for a number of physiological disorders in mammals, including humans. Ion channels, including potassium channels, are found in all mammalian cells and are involved in the modulation of various physiological processes and normal cellular homeostasis. Potassium channels generally control the resting membrane potential, and the efflux of potassium ions
35 causes repolarization of the plasma membrane after cell depolarization. Potassium

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5 channel antagonists prevent repolarization and cause the cell to stay in the depolarized, excited state.

There are a number of potassium channel subtypes. Physiologically, one important subtype is the maxi-K channel, defined as high-conductance calcium-activated potassium channel, which is present in neuronal tissue and smooth muscle.

10 Intracellular calcium concentration ($\text{Ca}_{\text{sup.2+sub.i}}$) and membrane potential gate these channels. For example, maxi-K channels are opened to enable efflux of potassium ions by an increase in the intracellular $\text{Ca}_{\text{sub.2+}}$ concentration or by membrane depolarization (change in potential). Elevation of intracellular calcium concentration is required for neurotransmitter release, smooth muscle contraction,
15 proliferation of some cell types and other processes. Modulation of maxi-K channel activity therefore affects cellular processes that depend on influx of calcium through voltage-dependent pathways, such as transmitter release from the nerve terminals and smooth muscle contraction.

A number of marketed drugs function as potassium channel antagonists. The
20 most important of these include the compounds Glyburide, Glipizide and Tolbutamide. These potassium channel antagonists are useful as antidiabetic agents. Potassium channel antagonists are also utilized as Class III antiarrhythmic agents and to treat acute infarctions in humans. A number of naturally occurring toxins are known to block potassium channels including apamin, iberiotoxin, charybdotoxin,
25 margatoxin, noxiustoxin, kaliotoxin, dendrotoxin(s), mast cell degranulating (MCD) peptide, and beta-bungarotoxin (beta-BTX). The K^+ -betaM5 polypeptides may be used in in vitro and in vivo models to test the specificity of novel compounds, and of analogs and derivatives of compounds known to act on potassium channels.

Depression is related to a decrease in neurotransmitter release. Current
30 treatments of depression include blockers of neurotransmitter uptake, and inhibitors of enzymes involved in neurotransmitter degradation which act to prolong the lifetime of neurotransmitters.

It is believed that certain diseases such as depression, memory disorders and Alzheimer's disease are the result of an impairment in neurotransmitter release.

35 Potassium channel antagonists may therefore be utilized as cell excitants which may stimulate release of neurotransmitters such as acetylcholine, serotonin and

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5 dopamine. Enhanced neurotransmitter release may reverse the symptoms associated with depression and Alzheimer's disease.

The K+betaM5 polynucleotides and polypeptides of the present invention, including agonists and/or fragments thereof, have uses that include modulating potassium channel activity in various cells, tissues, and organisms, and particularly in
 10 mammalian testis, spinal cord, lymph node, heart, uterus, small intestine, stomach, prostate, and kidney, preferably human. K+betaM5 polynucleotides and polypeptides of the present invention, including agonists and/or fragments thereof, may be useful in diagnosing, treating, prognosing, and/or preventing reproductive, neural, immune, cardiovascular, gastrointestinal, and renal diseases or disorders.

15 The strong homology to potassium channel beta subunits, combined with the predominately high expression in testis tissue emphasizes the potential utility for K+betaM5 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing testicular, in addition to reproductive disorders.

In preferred embodiments, K+betaM5 polynucleotides and polypeptides
 20 including agonists and fragments thereof, have uses which include treating, diagnosing, prognosing, and/or preventing the following, non-limiting, diseases or disorders of the testis: spermatogenesis, infertility, Klinefelter's syndrome, XX male, epididymitis, genital warts, germinal cell aplasia, cryptorchidism, varicocele, immotile cilia syndrome, and viral orchitis. The K+betaM5 polynucleotides and
 25 polypeptides including agonists and fragments thereof, may also have uses related to modulating testicular development, embryogenesis, reproduction, and in ameliorating, treating, and/or preventing testicular proliferative disorders (e.g., cancers, which include, for example, choriocarcinoma, Nonseminoma, seminoma, and testicular germ cell tumors).

30 Likewise, the localized expression in testis tissue also emphasizes the potential utility for K+betaM5 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing metabolic diseases and disorders which include the following, not limiting examples: premature puberty, incomplete puberty, Kallman syndrome, Cushing's syndrome, hyperprolactinemia, hemochromatosis, congenital
 35 adrenal hyperplasia, FSH deficiency, and granulomatous disease, for example.

5 This gene product may also be useful in assays designed to identify binding agents, as such agents (antagonists) are useful as male contraceptive agents. The testes are also a site of active gene expression of transcripts that is expressed, particularly at low levels, in other tissues of the body. Therefore, this gene product may be expressed in other specific tissues or organs where it may play related functional roles in other
10 processes, such as hematopoiesis, inflammation, bone formation, and kidney function, to name a few possible target indications.

The strong homology to human potassium channel beta subunit proteins, combined with the localized expression in spinal cord suggests the K+betaM5 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing,
15 and/or preventing neurodegenerative disease states, behavioral disorders, or inflammatory conditions. Representative uses are described in the “Regeneration” and “Hyperproliferative Disorders” sections below, in the Examples, and elsewhere herein. Briefly, the uses include, but are not limited to the detection, treatment, and/or prevention of Alzheimer’s Disease, Parkinson’s Disease, Huntington’s Disease,
20 Tourette Syndrome, meningitis, encephalitis, demyelinating diseases, peripheral neuropathies, neoplasia, trauma, congenital malformations, spinal cord injuries, ischemia and infarction, aneurysms, hemorrhages, schizophrenia, mania, dementia, paranoia, obsessive compulsive disorder, depression, panic disorder, learning disabilities, ALS, psychoses, autism, and altered behaviors, including disorders in
25 feeding, sleep patterns, balance, and perception. In addition, elevated expression of this gene product in regions of the brain indicates it plays a role in normal neural function. Potentially, this gene product is involved in synapse formation, neurotransmission, learning, cognition, homeostasis, or neuronal differentiation or survival. Furthermore, the protein may also be used to determine biological activity,
30 to raise antibodies, as tissue markers, to isolate cognate ligands or receptors, to identify agents that modulate their interactions, in addition to its use as a nutritional supplement. Protein, as well as, antibodies directed against the protein may show utility as a tumor marker and/or immunotherapy targets for the above listed tissues.

The strong homology to human potassium channel beta subunits, combined
35 with the localized expression in lymph node tissue suggests the K+betaM5 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing,

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5 and/or preventing immune diseases and/or disorders. Representative uses are described in the "Immune Activity", "Chemotaxis", and "Infectious Disease" sections below, and elsewhere herein. Briefly, the strong expression in immune tissue indicates a role in regulating the proliferation; survival; differentiation; and/or activation of hematopoietic cell lineages, including blood stem cells.

10 The K β M5 polypeptide may also be useful as a preventative agent for immunological disorders including arthritis, asthma, immunodeficiency diseases such as AIDS, leukemia, rheumatoid arthritis, granulomatous disease, inflammatory bowel disease, sepsis, acne, neutropenia, neutrophilia, psoriasis, hypersensitivities, such as T-cell mediated cytotoxicity; immune reactions to transplanted organs and tissues,
15 such as host-versus-graft and graft-versus-host diseases, or autoimmunity disorders, such as autoimmune infertility, lense tissue injury, demyelination, systemic lupus erythematosus, drug induced hemolytic anemia, rheumatoid arthritis, Sjogren's disease, and scleroderma. Moreover, the protein may represent a secreted factor that influences the differentiation or behavior of other blood cells, or that recruits
20 hematopoietic cells to sites of injury. Thus, this gene product may be useful in the expansion of stem cells and committed progenitors of various blood lineages, and in the differentiation and/or proliferation of various cell types.

Moreover, the K β M5 polypeptide may be useful for modulating cytokine production, antigen presentation, or other processes, such as for boosting immune
25 responses, etc. Expression in cells of lymphoid origin, indicates the natural gene product would be involved in immune functions. Therefore it would also be useful as an agent for immunological disorders including arthritis, asthma, immunodeficiency diseases such as AIDS, leukemia, rheumatoid arthritis, granulomatous disease, inflammatory bowel disease, sepsis, acne, neutropenia, neutrophilia, psoriasis,
30 hypersensitivities, such as T-cell mediated cytotoxicity; immune reactions to transplanted organs and tissues, such as host-versus-graft and graft-versus-host diseases, or autoimmunity disorders, such as autoimmune infertility, lense tissue injury, demyelination, systemic lupus erythematosus, drug induced hemolytic anemia, rheumatoid arthritis, Sjogren's disease, and scleroderma.

35 Moreover, the protein may represent a secreted factor that influences the differentiation or behavior of other blood cells, or that recruits hematopoietic cells to

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5 sites of injury. Thus, this gene product is thought to be useful in the expansion of stem cells and committed progenitors of various blood lineages, and in the differentiation and/or proliferation of various cell types. Furthermore, the protein may also be used to determine biological activity, raise antibodies, as tissue markers, to isolate cognate ligands or receptors, to identify agents that modulate their interactions, in addition to
10 its use as a nutritional supplement. Protein, as well as, antibodies directed against the protein may show utility as a tumor marker and/or immunotherapy targets for the above listed tissues.

The strong homology to human potassium channel beta subunits, combined with the predominate localized expression in heart tissue suggests the K⁺betaM5
15 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing cardiovascular diseases and/or disorders, which include, but are not limited to: myocardial infarction, congestive heart failure, arrhythmias, cardiomyopathy, atherosclerosis, arteriosclerosis, microvascular disease, embolism, thrombosis, pulmonary edema, palpitation, dyspnea, angina, hypotension, syncope,
20 heart murmur, aberrant ECG, hypertrophic cardiomyopathy, the Marfan syndrome, sudden death, prolonged QT syndrome, congenital defects, cardiac viral infections, valvular heart disease, and hypertension.

Similarly, K⁺betaM5 polynucleotides and polypeptides may be useful for ameliorating cardiovascular diseases and symptoms which result indirectly from
25 various non-cardiovascular effects, which include, but are not limited to, the following, obesity, smoking, Down syndrome (associated with endocardial cushion defect); bony abnormalities of the upper extremities (associated with atrial septal defect in the Holt-Oram syndrome); muscular dystrophies (associated with cardiomyopathy); hemochromatosis and glycogen storage disease (associated with
30 myocardial infiltration and restrictive cardiomyopathy); congenital deafness (associated with prolonged QT interval and serious cardiac arrhythmias); Raynaud's disease (associated with primary pulmonary hypertension and coronary vasospasm); connective tissue disorders, i.e., the Marfan syndrome, Ehlers-Danlos and Hurler syndromes, and related disorders of mucopolysaccharide metabolism (aortic
35 dilatation, prolapsed mitral valve, a variety of arterial abnormalities); acromegaly (hypertension, accelerated coronary atherosclerosis, conduction defects,

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5 cardiomyopathy); hyperthyroidism (heart failure, atrial fibrillation); hypothyroidism (pericardial effusion, coronary artery disease); rheumatoid arthritis (pericarditis, aortic valve disease); scleroderma (cor pulmonale, myocardial fibrosis, pericarditis); systemic lupus erythematosus (valvulitis, myocarditis, pericarditis); sarcoidosis (arrhythmias, cardiomyopathy); postmenopausal effects, Chlamydial infections,
 10 polycystic ovary disease, thyroid disease, alcoholism, diet, and exfoliative dermatitis (high-output heart failure), for example.

Moreover, polynucleotides and polypeptides, including fragments and/or antagonists thereof, have uses which include, directly or indirectly, treating, preventing, diagnosing, and/or prognosing the following, non-limiting, cardiovascular
 15 infections: blood stream invasion, bacteremia, sepsis, Streptococcus pneumoniae infection, group a streptococci infection, group b streptococci infection, Enterococcus infection, nonenterococcal group D streptococci infection, nonenterococcal group C streptococci infection, nonenterococcal group G streptococci infection, Streptococcus viridans infection, Staphylococcus aureus infection, coagulase-negative staphylococci
 20 infection, gram-negative Bacilli infection, Enterobacteriaceae infection, Pseudomonas spp. Infection, Acinobacter spp. Infection, Flavobacterium meningosepticum infection, Aeromonas spp. Infection, Stenotrophomonas maltophilia infection, gram-negative coccobacilli infection, Haemophilus influenza infection, Branhamella catarrhalis infection, anaerobe infection, Bacteriodes fragilis infection, Clostridium
 25 infection, fungal infection, Candida spp. Infection, non-albicans Candida spp. Infection, Hansenula anomala infection, Malassezia furfur infection, nontuberculous Mycobacteria infection, Mycobacterium avium infection, Mycobacterium chelonae infection, Mycobacterium fortuitum infection, spirochetal infection, Borrelia burgdorferi infection, in addition to any other cardiovascular disease and/or disorder
 30 (e.g., non-sepsis) implicated by the causative agents listed above or elsewhere herein.

The strong homology to potassium channel beta subunits, combined with the localized expression in uterus tissue emphasizes the potential utility for K⁺betaM5 polynucleotides and polypeptides in treating, diagnosing, prognosing, and/or preventing uterine, in addition to reproductive disorders.

35 In preferred embodiments, K⁺betaM5 polynucleotides and polypeptides including agonists and fragments thereof, have uses which include treating,

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5 diagnosing, prognosing, and/or preventing the following, non-limiting, diseases or disorders of the uterus: dysfunctional uterine bleeding, amenorrhea, primary dysmenorrhea, sexual dysfunction, infertility, pelvic inflammatory disease, endometriosis, placental aromatase deficiency, premature menopause, and placental dysfunction.

10 The strong homology to human potassium channel beta subunits, combined with the localized expression in small intestine and stomach suggests the K⁺betaM5 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing gastrointestinal diseases and/or disorders, which include, but are not limited to, ulcers, irritable bowel syndrome, inflammatory bowel disease, diarrhea,
15 traveler's diarrhea, drug-related diarrhea polyps, absorption disorders, constipation, diverticulitis, vascular disease of the intestines, intestinal obstruction, intestinal infections, ulcerative colitis, Shigellosis, cholera, Crohn's Disease, amebiasis, enteric fever, Whipple's Disease, peritonitis, intrabdominal abscesses, hereditary hemochromatosis, gastroenteritis, viral gastroenteritis, food poisoning, mesenteric
20 ischemia, mesenteric infarction, in addition to, metabolic diseases and/or disorders.

Moreover, K⁺betaM5 polynucleotides and polypeptides, including fragments and/or antagonists thereof, have uses which include, directly or indirectly, treating, preventing, diagnosing, and/or prognosing susceptibility to the following, non-limiting, gastrointestinal infections: Salmonella infection, E.coli infection, E.coli
25 O157:H7 infection, Shiga Toxin-producing E.coli infection, Campylobacter infection (e.g., Campylobacter fetus, Campylobacter upsaliensis, Campylobacter hyointestinalis, Campylobacter lari, Campylobacter jejuni, Campylobacter concisus, Campylobacter mucosalis, Campylobacter sputorum, Campylobacter rectus, Campylobacter curvus, Campylobacter sputorum, etc.), Heliobacter infection (e.g.,
30 Heliobacter cinaedi, Heliobacter fennelliae, etc.) Yersinia enterocolitica infection, Vibrio sp. Infection (e.g., Vibrio mimicus, Vibrio parahaemolyticus, Vibrio fluvialis, Vibrio furnissii, Vibrio hollisae, Vibrio vulnificus, Vibrio alginolyticus, Vibrio metschnikovii, Vibrio damsela, Vibrio cincinnatiensis, etc.) Aeromonas infection (e.g., Aeromonas hydrophila, Aeromonas sobira, Aeromonas caviae, etc.),
35 Plesiomonas shigelliodes infection, Giardia infection (e.g., Giardia lamblia, etc.), Cryptosporidium infection, Listeria infection, Entamoeba histolytica infection,

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5 Rotavirus infection, Norwalk virus infection, Clostridium difficile infection, Clostridium perfringens infection, Staphylococcus infection, Bacillus infection, in addition to any other gastrointestinal disease and/or disorder implicated by the causative agents listed above or elsewhere herein.

The strong homology to human potassium channel beta subunits, combined
 10 with the localized expression in kidney tissue suggests the K⁺betaM5 polynucleotides and polypeptides may be useful in treating, diagnosing, prognosing, and/or preventing renal diseases and/or disorders, which include, but are not limited to: nephritis, renal failure, nephrotic syndrome, urinary tract infection, hematuria, proteinuria, oliguria, polyuria, nocturia, edema, hypertension, electrolyte disorders, sterile pyuria, renal
 15 osteodystrophy, large kidneys, renal transport defects, nephrolithiasis, azotemia, anuria, urinary retention, slowing of urinary stream, large prostate, flank tenderness, full bladder sensation after voiding, enuresis, dysuria, bacteriuria, kidney stones, glomerulonephritis, vasculitis, hemolytic uremic syndromes, thrombotic thrombocytopenic purpura, malignant hypertension, casts, tubulointerstitial kidney
 20 diseases, renal tubular acidosis, pyelonephritis, hydronephritis, nephrotic syndrome, crush syndrome, and/or renal colic, in addition to Wilm's Tumor Disease, and congenital kidney abnormalities such as horseshoe kidney, polycystic kidney, and Falconi's syndrome, for example.

The K⁺betaM5 polynucleotides and polypeptides also have uses which
 25 include, but are not limited to treating, diagnosing, prognosing, and/or preventing proliferative disorders which include the following non-limiting examples: carcinoid tumor, islet cell carcinoma, Zollinger-Ellison gastrinoma, insulinoma, vipoma, glucagonoma, somatostatinoma, grfoma, crfoma, ppoma, neurotensinoma, and small cell carcinoma.

30 In addition, antagonists of the K⁺betaM5 polynucleotides and polypeptides may have uses that include diagnosing, treating, prognosing, and/or preventing diseases or disorders related to hyper potassium channel beta subunit activity, which may include immune, hematopoietic, metabolic, gastrointestinal, renal, neural, and/or proliferative diseases or disorders.

35 Alternatively, K⁺betaM5 polypeptides of the invention, or agonists thereof, are administered to treat, prevent, prognose, and/or diagnose disorders involving

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5 excessive smooth muscle tone or excitability, which include, but are not limited to asthma, angina, hypertension, incontinence, pre-term labor, and irritable bowel syndrome.

The potential involvement of aberrant potassium channel beta subunits in intestinal disease has been noted due to the colocalization of the potassium channel
10 alpha subunit KNCQ1 with the potassium channel beta subunit KCNE3, and the ability of KCNE3 to significantly modulate KNCQ1 function (Schroeder, BC., Waldegger, S., Fehr, S., Bleich, M., Warth, R., Greger, R., Jentsch, TJ. *Nature*. 1, 403(6766):196-9, (2000)). It is believed that KCNE3 modulated cyclic AMP-stimulated intestinal chloride secretion and is involved in secretory diarrhoea and
15 cystic fibrosis.

Thus, K+betaM5 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include modulating cycline AMP stimulated intestinal chloride secretion, and ameliorating, treating, and/or preventing diarrhea and cystic fibrosis.

20 Recently, two large-conductance calcium-activated potassium (BK) channel beta subunits were identified hKCNMB3 and hKCNMB4 and characterized (Behrens, R., Nolting, A., Reimann, F., Schwarz, M., Waldschutz, R., Pongs, O, Lett., 474(1):99-106, (2000); Brenner, R., Jegla, TJ., Wickenden, A., Liu, Y., Aldrich, RW, J. Biol, Chem., 275(9):6453-61, (2000)). These beta subunits were shown to
25 significantly slow activation kinetics, led to a steeper apparent calcium sensitivity, and shifted the voltage range of BK current activation to more negative potentials of potassium channel upon coexpression. In addition, the resulting alpha/beta channels were not blocked by 100 nM charybdotoxin or iberiotoxin, and were activated by 17beta-estradiol. Of particular significance to the K+betaM5 polypeptide of the
30 present invention is the fact that the expression of hKCNMB3 is enriched in testis tissue.

Thus, K+betaM5 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include slowing activation kinetics of potassium channels, increasing calcium sensitivity of potassium channels, and/or
35 shifting the voltage range of potassium channel current activation to more negative potentials.

5 The present invention encompasses compositions comprising pharmaceutical effective amounts of the K+betaM5 polypeptide, and optionally further comprising effective amounts of 17beta-estradiol suitable for sufficiently activating the administered K+betaM5 polypeptides.

 Potassium channel beta subunits have also been shown to activate the ability
10 of potassium channel alpha subunits to inhibit potassium channel membrane excitability and neuron activation in brain (Wissmann, R., Baukrowitz, T., Kalbacher, H., Kalbitzer, HR., Ruppertsberg, JP., Pongs, O., Antz, C., Fakler, B, J. Biol, Chem., 274(50):35521-5, (1999)). Additional potassium channel beta subunits have also been shown in accelerate certain alpha subunits ability to inactivate delayed rectifier
15 channels, specifically Kv1.1 and Kv1.4 delta 1-110 (Heinemann, SH., Rettig, J., Graack, HR., Pongs, O, J. Physiol, Lond., 493 (Pt 3):625-33, (1996)).

 Thus, K+betaM5 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include accelerating potassium channel alpha subunits ability to inhibit and/or inactivate potassium channels, in addition to, activate
20 potassium channel alpha subunits ability to inactivate and/or inhibit potassium channels (Heinemann, SH., Rettig, J., Wunder, F., Pongs, O, Lett., 377(3):383-9, (1995)).

 Moreover, K+betaM5 polynucleotides and polypeptides, including fragments and agonists thereof, may have uses which include treating, diagnosing, prognosing,
25 and/or preventing some classes of disorders that may be affected by effective manipulation of Shaker-like potassium ion channels, either directly or indirectly, which include neurological disorders, tumor driven diseases, metabolic diseases, cardiac diseases, and autoimmune diseases. Examples of disease states and conditions from these and other classes, as well as affected normal body functions, encompass:
30 hypoglycemia, anoxia/hypoxia, renal disease, osteoporosis, hyperkalemia, hypokalemia, hypertension, Addison's disease, abnormal apoptosis, induced apoptosis, clotting, modulation of acetylcholine function, and modulation of monoaminesepilepsy, allergic encephalomyelitis, multiple sclerosis (any demylelinating disease), acute traverse myelitis, neurofibromatosis, cardioplegia,
35 cardiomyopathy, ischemia, ischemia reperfusion, cerebral ischemia, sickle cell anemia, cardiac arrhythmias, peripheral monocuropathy, polynucuropathy, Gullain-

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5 potassium channel inhibitors, which include, but are not limited to the drugs listed above, might indicate a function in modulating potassium channel function, for example. In the case of K+betaM5, testis, spinal cord, lymph node, heart, uterus, small intestine, stomach, prostate, and/or kidney tissue should be used to extract RNA to prepare the probe.

10 In addition, the function of the protein may be assessed by applying quantitative PCR methodology, for example. Real time quantitative PCR would provide the capability of following the expression of the K+betaM5 gene throughout development, for example. Quantitative PCR methodology requires only a nominal amount of tissue from each developmentally important step is needed to perform such
15 experiements. Therefore, the application of quantitative PCR methodology to refining the biological function of this polypeptide is encompassed by the present invention. Also encompassed by the present invention are quantitative PCR probes corresponding to the polynucleotide sequence provided as SEQ ID NO:23 (Figures 6A-C).

20 The function of the protein may also be assessed through complementation assays in yeast. For example, in the case of the K+betaM5, transforming yeast deficient in potassium channel beta subunit activity and assessing their ability to grow would provide convincing evidence the K+betaM5 polypeptide has potassium channel beta subunit activity. Additional assay conditions and methods that may be used in
25 assessing the function of the polynucletides and polypeptides of the present invention are known in the art, some of which are disclosed elsewhere herein.

Alternatively, the biological function of the encoded polypeptide may be determined by disrupting a homologue of this polypeptide in Mice and/or rats and observing the resulting phenotype.

30 Moreover, the biological function of this polypeptide may be determined by the application of antisense and/or sense methodology and the resulting generation of transgenic mice and/or rats. Expressing a particular gene in either sense or antisense orientation in a transgenic mouse or rat could lead to respectively higher or lower expression levels of that particular gene. Altering the endogenous expression levels of
35 a gene can lead to the obervation of a particular phenotype that can then be used to derive indications on the function of the gene. The gene can be either over-expressed

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5 or under expressed in every cell of the organism at all times using a strong ubiquitous promoter, or it could be expressed in one or more discrete parts of the organism using a well characterized tissue-specific promoter (e.g., a testis, spinal cord, lymph node, heart, uterus, small intestine, stomach, prostate, and kidney-specific promoter), or it can be expressed at a specified time of development using an inducible and/or a
10 developmentally regulated promoter.

In the case of K+betaM5 transgenic mice or rats, if no phenotype is apparent in normal growth conditions, observing the organism under diseased conditions (reproductive, neural, cardiovascular, gastrointestinal, renal, or proliferative disorders, etc.) may lead to understanding the function of the gene. Therefore, the application of
15 antisense and/or sense methodology to the creation of transgenic mice or rats to refine the biological function of the polypeptide is encompassed by the present invention.

In preferred embodiments, the following N-terminal K+betaM5 deletion polypeptides are encompassed by the present invention: M1-G343, T2-G343, M3-G343, A4-G343, V5-G343, L6-G343, R7-G343, N8-G343, R9-G343, K10-G343,
20 G11-G343, G12-G343, K13-G343, G14-G343, P15-G343, L16-G343, R17-G343, R18-G343, R19-G343, P20-G343, L21-G343, A22-G343, L23-G343, P24-G343, A25-G343, L26-G343, R27-G343, L28-G343, G29-G343, E30-G343, L31-G343, P32-G343, A33-G343, N34-G343, Q35-G343, G36-G343, G37-G343, T38-G343, S39-G343, A40-G343, A41-G343, S42-G343, A43-G343, S44-G343, S45-G343,
25 G46-G343, R47-G343, R48-G343, S49-G343, G50-G343, Q51-G343, A52-G343, P53-G343, A54-G343, G55-G343, R56-G343, E57-G343, R58-G343, V59-G343, G60-G343, V61-G343, E62-G343, G63-G343, A64-G343, T65-G343, A66-G343, L67-G343, P68-G343, P69-G343, A70-G343, H71-G343, C72-G343, L73-G343, S74-G343, P75-G343, P76-G343, S77-G343, G78-G343, Q79-G343, P80-G343,
30 A81-G343, A82-G343, G83-G343, R84-G343, V85-G343, M86-G343, P87-G343, G88-G343, A89-G343, A90-G343, R91-G343, R92-G343, A93-G343, R94-G343, G95-G343, M96-G343, V97-G343, V98-G343, V99-G343, T100-G343, G101-G343, R102-G343, E103-G343, P104-G343, D105-G343, S106-G343, R107-G343, R108-G343, Q109-G343, D110-G343, G111-G343, A112-G343, M113-G343, S114-G343,
35 S115-G343, S116-G343, D117-G343, A118-G343, E119-G343, D120-G343, D121-G343, F122-G343, L123-G343, E124-G343, P125-G343, A126-G343, T127-G343,

5 P128-G343, T129-G343, A130-G343, T131-G343, Q132-G343, A133-G343, G134-G343, H135-G343, A136-G343, L137-G343, P138-G343, L139-G343, L140-G343, P141-G343, Q142-G343, E143-G343, F144-G343, P145-G343, E146-G343, V147-G343, V148-G343, P149-G343, L150-G343, N151-G343, I152-G343, G153-G343, G154-G343, A155-G343, H156-G343, F157-G343, T158-G343, T159-G343, R160-
10 G343, L161-G343, S162-G343, T163-G343, L164-G343, R165-G343, C166-G343, Y167-G343, E168-G343, D169-G343, T170-G343, M171-G343, L172-G343, A173-G343, A174-G343, M175-G343, F176-G343, S177-G343, G178-G343, R179-G343, H180-G343, Y181-G343, I182-G343, P183-G343, T184-G343, D185-G343, S186-G343, E187-G343, G188-G343, R189-G343, Y190-G343, F191-G343, I192-G343,
15 D193-G343, R194-G343, D195-G343, G196-G343, T197-G343, H198-G343, F199-G343, G200-G343, D201-G343, V202-G343, L203-G343, N204-G343, F205-G343, L206-G343, R207-G343, S208-G343, G209-G343, D210-G343, L211-G343, P212-G343, P213-G343, R214-G343, E215-G343, R216-G343, V217-G343, R218-G343, A219-G343, V220-G343, Y221-G343, K222-G343, E223-G343, A224-G343, Q225-
20 G343, Y226-G343, Y227-G343, A228-G343, I229-G343, G230-G343, P231-G343, L232-G343, L233-G343, E234-G343, Q235-G343, L236-G343, E237-G343, N238-G343, M239-G343, Q240-G343, P241-G343, L242-G343, K243-G343, G244-G343, E245-G343, K246-G343, V247-G343, R248-G343, Q249-G343, A250-G343, F251-G343, L252-G343, G253-G343, L254-G343, M255-G343, P256-G343, Y257-G343,
25 Y258-G343, K259-G343, D260-G343, H261-G343, L262-G343, E263-G343, R264-G343, I265-G343, V266-G343, E267-G343, I268-G343, A269-G343, R270-G343, L271-G343, R272-G343, A273-G343, V274-G343, Q275-G343, R276-G343, K277-G343, A278-G343, R279-G343, F280-G343, A281-G343, K282-G343, L283-G343, K284-G343, S285-G343, L286-G343, T287-G343, P288-G343, S289-G343, W290-
30 G343, L291-G343, M292-G343, S293-G343, V294-G343, L295-G343, I296-G343, K297-G343, M298-G343, P299-G343, P300-G343, G301-G343, V302-G343, T303-G343, S304-G343, W305-G343, I306-G343, N307-G343, A308-G343, E309-G343, R310-G343, R311-G343, L312-G343, Y313-G343, L314-G343, E315-G343, T316-G343, P317-G343, I318-G343, G319-G343, P320-G343, E321-G343, R322-G343,
35 Q323-G343, N324-G343, N325-G343, E326-G343, K327-G343, K328-G343, S329-G343, P330-G343, V331-G343, Q332-G343, L333-G343, P334-G343, A335-G343,

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- 5 G336-G343, and/or V337-G343 of SEQ ID NO:24. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these N-terminal K+betaM5 deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

In preferred embodiments, the following C-terminal K+betaM5 deletion
 10 polypeptides are encompassed by the present invention: M1-G343, M1-M342, M1-F341, M1-H340, M1-Q339, M1-F338, M1-V337, M1-G336, M1-A335, M1-P334, M1-L333, M1-Q332, M1-V331, M1-P330, M1-S329, M1-K328, M1-K327, M1-E326, M1-N325, M1-N324, M1-Q323, M1-R322, M1-E321, M1-P320, M1-G319, M1-I318, M1-P317, M1-T316, M1-E315, M1-L314, M1-Y313, M1-L312, M1-R311,
 15 M1-R310, M1-E309, M1-A308, M1-N307, M1-I306, M1-W305, M1-S304, M1-T303, M1-V302, M1-G301, M1-P300, M1-P299, M1-M298, M1-K297, M1-I296, M1-L295, M1-V294, M1-S293, M1-M292, M1-L291, M1-W290, M1-S289, M1-P288, M1-T287, M1-L286, M1-S285, M1-K284, M1-L283, M1-K282, M1-A281, M1-F280, M1-R279, M1-A278, M1-K277, M1-R276, M1-Q275, M1-V274, M1-A273, M1-R272, M1-L271, M1-R270, M1-A269, M1-I268, M1-E267, M1-V266, M1-I265, M1-R264, M1-E263, M1-L262, M1-H261, M1-D260, M1-K259, M1-Y258, M1-Y257, M1-P256, M1-M255, M1-L254, M1-G253, M1-L252, M1-F251, M1-A250, M1-Q249, M1-R248, M1-V247, M1-K246, M1-E245, M1-G244, M1-K243, M1-L242, M1-P241, M1-Q240, M1-M239, M1-N238, M1-E237, M1-L236,
 20 M1-Q235, M1-E234, M1-L233, M1-L232, M1-P231, M1-G230, M1-I229, M1-A228, M1-Y227, M1-Y226, M1-Q225, M1-A224, M1-E223, M1-K222, M1-Y221, M1-V220, M1-A219, M1-R218, M1-V217, M1-R216, M1-E215, M1-R214, M1-P213, M1-P212, M1-L211, M1-D210, M1-G209, M1-S208, M1-R207, M1-L206, M1-F205, M1-N204, M1-L203, M1-V202, M1-D201, M1-G200, M1-F199, M1-H198, M1-T197, M1-G196, M1-D195, M1-R194, M1-D193, M1-I192, M1-F191, M1-Y190, M1-R189, M1-G188, M1-E187, M1-S186, M1-D185, M1-T184, M1-P183, M1-I182, M1-Y181, M1-H180, M1-R179, M1-G178, M1-S177, M1-F176, M1-M175, M1-A174, M1-A173, M1-L172, M1-M171, M1-T170, M1-D169, M1-E168, M1-Y167, M1-C166, M1-R165, M1-L164, M1-T163, M1-S162, M1-L161, M1-R160, M1-T159,
 30 M1-T158, M1-F157, M1-H156, M1-A155, M1-G154, M1-G153, M1-I152, M1-N151, M1-L150, M1-P149, M1-V148, M1-V147, M1-E146, M1-P145, M1-F144,

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5 M1-E143, M1-Q142, M1-P141, M1-L140, M1-L139, M1-P138, M1-L137, M1-A136, M1-H135, M1-G134, M1-A133, M1-Q132, M1-T131, M1-A130, M1-T129, M1-P128, M1-T127, M1-A126, M1-P125, M1-E124, M1-L123, M1-F122, M1-D121, M1-D120, M1-E119, M1-A118, M1-D117, M1-S116, M1-S115, M1-S114, M1-M113, M1-A112, M1-G111, M1-D110, M1-Q109, M1-R108, M1-R107, M1-S106,
10 M1-D105, M1-P104, M1-E103, M1-R102, M1-G101, M1-T100, M1-V99, M1-V98, M1-V97, M1-M96, M1-G95, M1-R94, M1-A93, M1-R92, M1-R91, M1-A90, M1-A89, M1-G88, M1-P87, M1-M86, M1-V85, M1-R84, M1-G83, M1-A82, M1-A81, M1-P80, M1-Q79, M1-G78, M1-S77, M1-P76, M1-P75, M1-S74, M1-L73, M1-C72, M1-H71, M1-A70, M1-P69, M1-P68, M1-L67, M1-A66, M1-T65, M1-A64, M1-G63, M1-E62, M1-V61, M1-G60, M1-V59, M1-R58, M1-E57, M1-R56, M1-G55,
15 M1-A54, M1-P53, M1-A52, M1-Q51, M1-G50, M1-S49, M1-R48, M1-R47, M1-G46, M1-S45, M1-S44, M1-A43, M1-S42, M1-A41, M1-A40, M1-S39, M1-T38, M1-G37, M1-G36, M1-Q35, M1-N34, M1-A33, M1-P32, M1-L31, M1-E30, M1-G29, M1-L28, M1-R27, M1-L26, M1-A25, M1-P24, M1-L23, M1-A22, M1-L21, M1-P20, M1-R19, M1-R18, M1-R17, M1-L16, M1-P15, M1-G14, M1-K13, M1-G12, M1-G11, M1-K10, M1-R9, M1-N8, and/or M1-R7 of SEQ ID NO:24. Polynucleotide sequences encoding these polypeptides are also provided. The present invention also encompasses the use of these C-terminal K+betaM5 deletion polypeptides as immunogenic and/or antigenic epitopes as described elsewhere
25 herein.

Alternatively, preferred polypeptides of the present invention may comprise polypeptide sequences corresponding to, for example, internal regions of the K+betaM5 polypeptide (e.g., any combination of both N- and C- terminal K+betaM5 polypeptide deletions) of SEQ ID NO:24. For example, internal regions could be
30 defined by the equation: amino acid NX to amino acid CX, wherein NX refers to any N-terminal deletion polypeptide amino acid of K+betaM5 (SEQ ID NO:24), and where CX refers to any C-terminal deletion polypeptide amino acid of K+betaM5 (SEQ ID NO:24). Polynucleotides encoding these polypeptides are also provided. The present invention also encompasses the use of these polypeptides as an immunogenic
35 and/or antigenic epitope as described elsewhere herein.

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5 domain analysis algorithm (Bateman, A., Birney, E. R., Durbin, S. R., Eddy, S. R.,
Howe, K. L., and Sonnhammer, E. L. L., Nucleic Acids Research 28, 263-266
(2000)). In this context, the term "about" should be construed to mean 1, 2, 3, 4, 5, 6,
7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 more amino acids in either the N-
or C-terminal direction of the above referenced polypeptide. Polynucleotides
10 encoding these polypeptides are also provided.

The N-terminal, cytoplasmic tetramerization domain (T1) of voltage-gated K⁺
channels encodes molecular determinants for subfamily-specific assembly of alpha-
subunits into functional tetrameric channels (Bixby et al., 1999). It is distantly related
to the BTB/POZ domain BTB. The presence of such a domain within a potassium
15 channel beta-subunit may be required for associating with potassium channel alpha
subunits and potassium channels. Such a domain may also be required for the beta –
subunits ability to modulate potassium channel function.

Preferred polypeptides of the invention comprise the following amino acid
sequence:
20 EVVPLNIGGAHFTTRLSTLRCYEDTMLAAMFSGRHYIPTDSEGRYFIDRDGTH
FGDVLNFLRSGDLPPRERVRAVYKEAQYYAIGPLLEQLENMQP (SEQ ID
NO:39). Polynucleotides encoding these polypeptides are also provided. The present
invention also encompasses the use of this K+betaM5 tetramerisation domain
polypeptides as immunogenic and/or antigenic epitopes as described elsewhere
25 herein.

The K+betaM5 polypeptides of the present invention were determined to
comprise several phosphorylation sites based upon the Motif algorithm (Genetics
Computer Group, Inc.). The phosphorylation of such sites may regulate some
biological activity of the K+betaM5 polypeptide. For example, phosphorylation at
30 specific sites may be involved in regulating the proteins ability to associate or bind to
other molecules (e.g., proteins, ligands, substrates, DNA, etc.). In the present case,
phosphorylation may modulate the ability of the K+betaM5 polypeptide to associate
with other potassium channel alpha subunits, beta subunits, or its ability to modulate
potassium channel function.

35 The K+betaM5 polypeptide was predicted to comprise six PKC
phosphorylation sites using the Motif algorithm (Genetics Computer Group, Inc.). In

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5 vivo, protein kinase C exhibits a preference for the phosphorylation of serine or threonine residues. The PKC phosphorylation sites have the following consensus pattern: [ST]-x-[RK], where S or T represents the site of phosphorylation and 'x' an intervening amino acid residue. Additional information regarding PKC phosphorylation sites can be found in Woodget J.R., Gould K.L., Hunter T., Eur. J. Biochem. 161:177-184(1986), and Kishimoto A., Nishiyama K., Nakanishi H., Uratsuji Y., Nomura H., Takeyama Y., Nishizuka Y., J. Biol. Chem. 260:12492-12499(1985); which are hereby incorporated by reference herein.

In preferred embodiments, the following PKC phosphorylation site polypeptides are encompassed by the present invention: AASASSGRRSGQA (SEQ ID NO:33), GMVVVTGREPDSR (SEQ ID NO:34), GREPDSRRQDGAM (SEQ ID NO:35), GGAHFTTRLSTLR (SEQ ID NO:36), TTRLSTLR CYEDT (SEQ ID NO:37), and/or LAAMFSGRHYIPT (SEQ ID NO:38). Polynucleotides encoding these polypeptides are also provided. The present invention also encompasses the use of these K+betaM5 PKC phosphorylation site polypeptides as immunogenic and/or antigenic epitopes as described elsewhere herein.

The K+betaM5 polypeptide has been shown to comprise one amidation site according to the Motif algorithm (Genetics Computer Group, Inc.). The precursor of hormones and other active peptides which are C-terminally amidated is always directly followed by a glycine residue which provides the amide group, and most often by at least two consecutive basic residues (Arg or Lys) which generally function as an active peptide precursor cleavage site. Although all amino acids can be amidated, neutral hydrophobic residues such as Val or Phe are good substrates, while charged residues such as Asp or Arg are much less reactive. A consensus pattern for amidation sites is the following: x-G-[RK]-[RK], wherein "X" represents the amidation site. Additional information relating to asparagine glycosylation may be found in reference to the following publications, which are hereby incorporated by reference herein: Kreil G., Meth. Enzymol. 106:218-223(1984); and Bradbury A.F., Smyth D.G., Biosci. Rep. 7:907-916(1987).

In preferred embodiments, the following amidation site polypeptide is encompassed by the present invention: AASASSGRRSGQAP (SEQ ID NO:51). Polynucleotides encoding these polypeptides are also provided. The present invention

5 also encompasses the use of this K+betaM5 amidation site polypeptide as an immunogenic and/or antigenic epitope as described elsewhere herein.

The present invention also encompasses immunogenic and/or antigenic epitopes of the K+betaM5 polypeptide.

Many polynucleotide sequences, such as EST sequences, are publicly available and accessible through sequence databases. Some of these sequences are related to SEQ ID NO:23 and may have been publicly available prior to conception of the present invention. Preferably, such related polynucleotides are specifically excluded from the scope of the present invention. To list every related sequence would be cumbersome. Accordingly, preferably excluded from the present invention are one or more polynucleotides consisting of a nucleotide sequence described by the general formula of a-b, where a is any integer between 1 to 2150 of SEQ ID NO:23, b is an integer between 15 to 2154, where both a and b correspond to the positions of nucleotide residues shown in SEQ ID NO:23, and where b is greater than or equal to a+14.

Table I

Gene No.	CDNA CloneID	ATCC Deposit No. Z and Date	Vector	NT SEQ ID. No. X	Total NT Seq of Clone	5' NT of Start Codon of ORF	3' NT of ORF	AA Seq ID No. Y	Total AA of ORF
1.	K+betaM4 (2BAC-18)	XXXXX xx/xx/xx	Psport1	1	1839	5	1057	2	350
2.	K+betaM5 (2BAC-3)	XXXXX xx/xx/xx	Psport1	23	2154	1	1029	24	343

Table 1 summarizes the information corresponding to each "Gene No." described above. The nucleotide sequence identified as "NT SEQ ID NO:1" was assembled from partially homologous ("overlapping") sequences obtained from the "cDNA clone ID" identified in Table 1 and, in some cases, from additional related DNA clones. The overlapping sequences were assembled into a single contiguous sequence of high redundancy (usually several overlapping sequences at each nucleotide position), resulting in a final sequence identified as SEQ ID NO:1.

The cDNA Clone ID was deposited on the date and given the corresponding deposit number listed in "ATCC Deposit No:Z and Date." "Vector" refers to the type of vector contained in the cDNA Clone ID.

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5 “Total NT Seq. Of Clone” refers to the total number of nucleotides in the clone contig identified by “Gene No.” The deposited clone may contain all or most of the sequence of SEQ ID NO:1. The nucleotide position of SEQ ID NO:1 of the putative start codon (methionine) is identified as “5’ NT of Start Codon of ORF.”

10 The translated amino acid sequence, beginning with the methionine, is identified as “AA SEQ ID NO:2,” although other reading frames can also be easily translated using known molecular biology techniques. The polypeptides produced by these alternative open reading frames are specifically contemplated by the present invention.

15 The total number of amino acids within the open reading frame of SEQ ID NO:2 is identified as “Total AA of ORF”.

20 SEQ ID NO:1 (where X may be any of the polynucleotide sequences disclosed in the sequence listing) and the translated SEQ ID NO:2 (where Y may be any of the polypeptide sequences disclosed in the sequence listing) are sufficiently accurate and otherwise suitable for a variety of uses well known in the art and described further herein. For instance, SEQ ID NO:1 is useful for designing nucleic acid hybridization probes that will detect nucleic acid sequences contained in SEQ ID NO:1 or the cDNA contained in the deposited clone. These probes will also hybridize to nucleic acid molecules in biological samples, thereby enabling a variety of forensic and diagnostic methods of the invention. Similarly, polypeptides identified from SEQ ID
25 NO:2 may be used, for example, to generate antibodies which bind specifically to proteins containing the polypeptides and the proteins encoded by the cDNA clones identified in Table 1.

30 Nevertheless, DNA sequences generated by sequencing reactions can contain sequencing errors. The errors exist as misidentified nucleotides, or as insertions or deletions of nucleotides in the generated DNA sequence. The erroneously inserted or deleted nucleotides may cause frame shifts in the reading frames of the predicted amino acid sequence. In these cases, the predicted amino acid sequence diverges from the actual amino acid sequence, even though the generated DNA sequence may be greater than 99.9% identical to the actual DNA sequence (for example, one base
35 insertion or deletion in an open reading frame of over 1000 bases).

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5 Accordingly, for those applications requiring precision in the nucleotide sequence or the amino acid sequence, the present invention provides not only the generated nucleotide sequence identified as SEQ ID NO:1 or SEQ ID NO:23 and the predicted translated amino acid sequence identified as SEQ ID NO:2 or SEQ ID NO:24, but also a sample of plasmid DNA containing a cDNA of the invention
10 deposited with the ATCC, as set forth in Table 1. The nucleotide sequence of each deposited clone can readily be determined by sequencing the deposited clone in accordance with known methods. The predicted amino acid sequence can then be verified from such deposits. Moreover, the amino acid sequence of the protein encoded by a particular clone can also be directly determined by peptide sequencing
15 or by expressing the protein in a suitable host cell containing the deposited cDNA, collecting the protein, and determining its sequence.

 The present invention also relates to the genes corresponding to SEQ ID NO:1, or SEQ ID NO:23, or the deposited clone. The corresponding gene can be isolated in accordance with known methods using the sequence information disclosed
20 herein. Such methods include preparing probes or primers from the disclosed sequence and identifying or amplifying the corresponding gene from appropriate sources of genomic material.

 Also provided in the present invention are species homologs, allelic variants, and/or orthologs. The skilled artisan could, using procedures well-known in the art,
25 obtain the polynucleotide sequence corresponding to full-length genes (including, but not limited to the full-length coding region), allelic variants, splice variants, orthologs, and/or species homologues of genes corresponding to SEQ ID NO:1, or SEQ ID NO:23, or a deposited clone, relying on the sequence from the sequences disclosed herein or the clones deposited with the ATCC. For example, allelic variants and/or
30 species homologues may be isolated and identified by making suitable probes or primers which correspond to the 5', 3', or internal regions of the sequences provided herein and screening a suitable nucleic acid source for allelic variants and/or the desired homologue.

 The polypeptides of the invention can be prepared in any suitable manner.
35 Such polypeptides include isolated naturally occurring polypeptides, recombinantly produced polypeptides, synthetically produced polypeptides, or polypeptides

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5 produced by a combination of these methods. Means for preparing such polypeptides are well understood in the art.

The polypeptides may be in the form of the protein, or may be a part of a larger protein, such as a fusion protein (see below). It is often advantageous to include an additional amino acid sequence which contains secretory or leader sequences, pro-
 10 sequences, sequences which aid in purification, such as multiple histidine residues, or an additional sequence for stability during recombinant production.

The polypeptides of the present invention are preferably provided in an isolated form, and preferably are substantially purified. A recombinantly produced version of a polypeptide, can be substantially purified using techniques described
 15 herein or otherwise known in the art, such as, for example, by the one-step method described in Smith and Johnson, Gene 67:31-40 (1988). Polypeptides of the invention also can be purified from natural, synthetic or recombinant sources using protocols described herein or otherwise known in the art, such as, for example, antibodies of the invention raised against the full-length form of the protein.

20 The present invention provides a polynucleotide comprising, or alternatively consisting of, the sequence identified as SEQ ID NO:1, or SEQ ID NO:23, and/or a cDNA provided in ATCC Deposit No. Z:. The present invention also provides a polypeptide comprising, or alternatively consisting of, the sequence identified as SEQ ID NO:2, SEQ ID NO:24, and/or a polypeptide encoded by the cDNA provided in
 25 ATCC Deposit NO:Z. The present invention also provides polynucleotides encoding a polypeptide comprising, or alternatively consisting of the polypeptide sequence of SEQ ID NO:2, SEQ ID NO:24, and/or a polypeptide sequence encoded by the cDNA contained in ATCC Deposit No:Z.

30 Preferably, the present invention is directed to a polynucleotide comprising, or alternatively consisting of, the sequence identified as SEQ ID NO:1, or SEQ ID NO:23, and/or a cDNA provided in ATCC Deposit No.: that is less than, or equal to, a polynucleotide sequence that is 5 mega basepairs, 1 mega basepairs, 0.5 mega basepairs, 0.1 mega basepairs, 50,000 basepairs, 20,000 basepairs, or 10,000 basepairs in length.

35 The present invention encompasses polynucleotides with sequences complementary to those of the polynucleotides of the present invention disclosed

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5 herein. Such sequences may be complementary to the sequence disclosed as SEQ ID NO:1, or SEQ ID NO:23, the sequence contained in a deposit, and/or the nucleic acid sequence encoding the sequence disclosed as SEQ ID NO:2 or SEQ ID NO:24.

10 The present invention also encompasses polynucleotides capable of hybridizing, preferably under reduced stringency conditions, more preferably under stringent conditions, and most preferably under highly stringent conditions, to polynucleotides described herein. Examples of stringency conditions are shown in Table 2 below: highly stringent conditions are those that are at least as stringent as, for example, conditions A-F; stringent conditions are at least as stringent as, for example, conditions G-L; and reduced stringency conditions are at least as stringent
15 as, for example, conditions M-R.

5 **TABLE 2**

Stringency Condition	Polynucleotide Hybrid±	Hybrid Length (bp) ‡	Hyridization Temperature and Buffer†	Wash Temperature and Buffer †
A	DNA:DNA	> or equal to 50	65°C; 1xSSC –or– 42°C; 1xSSC, 50% formamide	65°C; 0.3xSSC
B	DNA:DNA	< 50	Tb*; 1xSSC	Tb*; 1xSSC
C	DNA:RNA	> or equal to 50	67°C; 1xSSC –or– 45°C; 1xSSC, 50% formamide	67°C; 0.3xSSC
D	DNA:RNA	< 50	Td*; 1xSSC	Td*; 1xSSC
E	RNA:RNA	> or equal to 50	70°C; 1xSSC –or– 50°C; 1xSSC, 50% formamide	70°C; 0.3xSSC
F	RNA:RNA	< 50	Tf*; 1xSSC	Tf*; 1xSSC
G	DNA:DNA	> or equal to 50	65°C; 4xSSC –or– 45°C; 4xSSC, 50% formamide	65°C; 1xSSC
H	DNA:DNA	< 50	Th*; 4xSSC	Th*; 4xSSC
I	DNA:RNA	> or equal to 50	67°C; 4xSSC –or– 45°C; 4xSSC, 50% formamide	67°C; 1xSSC
J	DNA:RNA	< 50	Tj*; 4xSSC	Tj*; 4xSSC
K	RNA:RNA	> or equal to 50	70°C; 4xSSC –or– 40°C; 6xSSC, 50% formamide	67°C; 1xSSC
L	RNA:RNA	< 50	Tl*; 2xSSC	Tl*; 2xSSC
M	DNA:DNA	> or equal to 50	50°C; 4xSSC –or– 40°C 6xSSC, 50% formamide	50°C; 2xSSC
N	DNA:DNA	< 50	Tn*; 6xSSC	Tn*; 6xSSC
O	DNA:RNA	> or equal to 50	55°C; 4xSSC –or– 42°C; 6xSSC, 50% formamide	55°C; 2xSSC
P	DNA:RNA	< 50	Tp*; 6xSSC	Tp*; 6xSSC

5

Stringency Condition	Polynucleotide Hybrid \pm	Hybrid Length (bp) \ddagger	Hybridization Temperature and Buffer \dagger	Wash Temperature and Buffer \dagger
Q	RNA:RNA	> or equal to 50	60°C; 4xSSC –or– 45°C; 6xSSC, 50% formamide	60°C; 2xSSC
R	RNA:RNA	< 50	Tr*; 4xSSC	Tr*; 4xSSC

\ddagger - The “hybrid length” is the anticipated length for the hybridized region(s) of the hybridizing polynucleotides. When hybridizing a polynucleotide of unknown sequence, the hybrid is assumed to be that of the hybridizing polynucleotide of the present invention. When polynucleotides of known sequence are hybridized, the hybrid length can be determined by aligning the sequences of the polynucleotides and identifying the region or regions of optimal sequence complementarity. Methods of aligning two or more polynucleotide sequences and/or determining the percent identity between two polynucleotide sequences are well known in the art (e.g., MegAlign program of the DNA*Star suite of programs, etc).

\dagger - SSPE (1xSSPE is 0.15M NaCl, 10mM NaH₂PO₄, and 1.25mM EDTA, pH 7.4) can be substituted for SSC (1xSSC is 0.15M NaCl and 15mM sodium citrate) in the hybridization and wash buffers; washes are performed for 15 minutes after hybridization is complete. The hybridizations and washes may additionally include 5X Denhardt's reagent, 5-1.0% SDS, 100ug/ml denatured, fragmented salmon sperm DNA, 0.5% sodium pyrophosphate, and up to 50% formamide.

*T_b – T_r: The hybridization temperature for hybrids anticipated to be less than 50 base pairs in length should be 5-10°C less than the melting temperature T_m of the hybrids there T_m is determined according to the following equations. For hybrids less than 18 base pairs in length, $T_m(^{\circ}\text{C}) = 2(\# \text{ of A} + \text{T bases}) + 4(\# \text{ of G} + \text{C bases})$. For hybrids between 18 and 49 base pairs in length, $T_m(^{\circ}\text{C}) = 81.5 + 16.6(\log_{10}[\text{Na}^+]) + 0.41(\% \text{G+C}) - (600/\text{N})$, where N is the number of bases in the hybrid, and [Na⁺] is the concentration of sodium ions in the hybridization buffer ([Na⁺] for 1xSSC = .165 M).

\pm - The present invention encompasses the substitution of any one, or more DNA or RNA hybrid partners with either a PNA, or a modified polynucleotide. Such

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5 modified polynucleotides are known in the art and are more particularly described elsewhere herein.

Additional examples of stringency conditions for polynucleotide hybridization are provided, for example, in Sambrook, J., E.F. Fritsch, and T. Maniatis, 1989, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Laboratory Press,
10 Cold Spring Harbor, NY, chapters 9 and 11, and Current Protocols in Molecular Biology, 1995, F.M., Ausubel et al., eds, John Wiley and Sons, Inc., sections 2.10 and 6.3-6.4, which are hereby incorporated by reference herein.

Preferably, such hybridizing polynucleotides have at least 70% sequence identity (more preferably, at least 80% identity; and most preferably at least 90% or
15 95% identity) with the polynucleotide of the present invention to which they hybridize, where sequence identity is determined by comparing the sequences of the hybridizing polynucleotides when aligned so as to maximize overlap and identity while minimizing sequence gaps. The determination of identity is well known in the art, and discussed more specifically elsewhere herein.

20 The invention encompasses the application of PCR methodology to the polynucleotide sequences of the present invention, the clone deposited with the ATCC, and/or the cDNA encoding the polypeptides of the present invention. PCR techniques for the amplification of nucleic acids are described in US Patent No. 4, 683, 195 and Saiki et al., Science, 239:487-491 (1988). PCR, for example, may
25 include the following steps, of denaturation of template nucleic acid (if double-stranded), annealing of primer to target, and polymerization. The nucleic acid probed or used as a template in the amplification reaction may be genomic DNA, cDNA, RNA, or a PNA. PCR may be used to amplify specific sequences from genomic DNA, specific RNA sequence, and/or cDNA transcribed from mRNA. References for
30 the general use of PCR techniques, including specific method parameters, include Mullis et al., Cold Spring Harbor Symp. Quant. Biol., 51:263, (1987), Ehrlich (ed), PCR Technology, Stockton Press, NY, 1989; Ehrlich et al., Science, 252:1643-1650, (1991); and "PCR Protocols, A Guide to Methods and Applications", Eds., Innis et al., Academic Press, New York, (1990).

35

Polynucleotide and Polypeptide Variants

5 The present invention also encompasses variants (e.g., allelic variants, orthologs, etc.) of the polynucleotide sequence disclosed herein in SEQ ID NO:1, the complementary strand thereto, SEQ ID NO:23, the complementary strand thereto, and/or the cDNA sequence contained in the deposited clone.

10 The present invention also encompasses variants of the polypeptide sequence, and/or fragments therein, disclosed in SEQ ID NO:2, SEQ ID NO:24, a polypeptide encoded by the polynucleotide sequence in SEQ ID NO:1, a polypeptide encoded by the polynucleotide sequence in SEQ ID NO:23, and/or a polypeptide encoded by a cDNA in the deposited clone.

15 "Variant" refers to a polynucleotide or polypeptide differing from the polynucleotide or polypeptide of the present invention, but retaining essential properties thereof. Generally, variants are overall closely similar, and, in many regions, identical to the polynucleotide or polypeptide of the present invention.

 Thus, one aspect of the invention provides an isolated nucleic acid molecule comprising, or alternatively consisting of, a polynucleotide having a nucleotide
20 sequence selected from the group consisting of: (a) a nucleotide sequence encoding a K+betaM4 related polypeptide having an amino acid sequence as shown in the sequence listing and described in SEQ ID NO:1, or SEQ ID NO:23, SEQ ID NO:23, or the cDNA contained in ATCC deposit No:Z; (b) a nucleotide sequence encoding a mature K+betaM4 related polypeptide having the amino acid sequence as shown in
25 the sequence listing and described in SEQ ID NO:1, or SEQ ID NO:23, or the cDNA contained in ATCC deposit No:Z; (c) a nucleotide sequence encoding a biologically active fragment of a K+betaM4 related polypeptide having an amino acid sequence shown in the sequence listing and described in SEQ ID NO:1, or SEQ ID NO:23, or the cDNA contained in ATCC deposit No:Z; (d) a nucleotide sequence encoding an
30 antigenic fragment of a K+betaM4 related polypeptide having an amino acid sequence shown in the sequence listing and described in SEQ ID NO:1, or SEQ ID NO:23, or the cDNA contained in ATCC deposit No:Z; (e) a nucleotide sequence encoding a K+betaM4 related polypeptide comprising the complete amino acid sequence encoded by a human cDNA plasmid contained in SEQ ID NO:1, or SEQ ID NO:23, or the
35 cDNA contained in ATCC deposit No:Z; (f) a nucleotide sequence encoding a mature K+betaM4 related polypeptide having an amino acid sequence encoded by a human

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5 cDNA plasmid contained in SEQ ID NO:1, or SEQ ID NO:23, or the cDNA
 contained in ATCC deposit No:Z; (g) a nucleotide sequence encoding a biologically
 active fragment of a K+betaM4 or K+betaM5 or K+betaM5 related polypeptide
 having an amino acid sequence encoded by a human cDNA plasmid contained in SEQ
 ID NO:1, or SEQ ID NO:23, or the cDNA contained in ATCC deposit No:Z; (h) a
 10 nucleotide sequence encoding an antigenic fragment of a K+betaM4 or K+betaM5
 related polypeptide having an amino acid sequence encoded by a human cDNA
 plasmid contained in SEQ ID NO:1, or SEQ ID NO:23, or the cDNA contained in
 ATCC deposit No:Z; (I) a nucleotide sequence complimentary to any of the
 nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), or (h), above.

15 The present invention is also directed to polynucleotide sequences which
 comprise, or alternatively consist of, a polynucleotide sequence which is at least about
 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%,
 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to, for example, any
 of the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), or (h), above.
 20 Polynucleotides encoded by these nucleic acid molecules are also encompassed by the
 invention. In another embodiment, the invention encompasses nucleic acid molecule
 which comprise, or alternatively, consist of a polynucleotide which hybridizes under
 stringent conditions, or alternatively, under lower stringency conditions, to a
 polynucleotide in (a), (b), (c), (d), (e), (f), (g), or (h), above. Polynucleotides which
 25 hybridize to the complement of these nucleic acid molecules under stringent
 hybridization conditions or alternatively, under lower stringency conditions, are also
 encompassed by the invention, as are polypeptides encoded by these polypeptides.

Another aspect of the invention provides an isolated nucleic acid molecule
 comprising, or alternatively, consisting of, a polynucleotide having a nucleotide
 30 sequence selected from the group consisting of: (a) a nucleotide sequence encoding a
 K+betaM4 or K+betaM5 related polypeptide having an amino acid sequence as
 shown in the sequence listing and described in Table 1; (b) a nucleotide sequence
 encoding a mature K+betaM4 or K+betaM5 related polypeptide having the amino
 acid sequence as shown in the sequence listing and described in Table 1; (c) a
 35 nucleotide sequence encoding a biologically active fragment of a K+betaM4 or
 K+betaM5 related polypeptide having an amino acid sequence as shown in the

5 sequence listing and described in Table 1; (d) a nucleotide sequence encoding an antigenic fragment of a K+betaM4 or K+betaM5 related polypeptide having an amino acid sequence as shown in the sequence listing and described in Table 1; (e) a nucleotide sequence encoding a K+betaM4 or K+betaM5 related polypeptide comprising the complete amino acid sequence encoded by a human cDNA in a cDNA
10 plasmid contained in the ATCC Deposit and described in Table 1; (f) a nucleotide sequence encoding a mature K+betaM4 or K+betaM5 related polypeptide having an amino acid sequence encoded by a human cDNA in a cDNA plasmid contained in the ATCC Deposit and described in Table 1; (g) a nucleotide sequence encoding a biologically active fragment of a K+betaM4 or K+betaM5 related polypeptide having
15 an amino acid sequence encoded by a human cDNA in a cDNA plasmid contained in the ATCC Deposit and described in Table 1; (h) a nucleotide sequence encoding an antigenic fragment of a K+betaM4 or K+betaM5 related polypeptide having an amino acid sequence encoded by a human cDNA in a cDNA plasmid contained in the ATCC deposit and described in Table 1; (i) a nucleotide sequence complimentary to any of
20 the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), or (h) above.

The present invention is also directed to nucleic acid molecules which comprise, or alternatively, consist of, a nucleotide sequence which is at least about 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to, for example, any
25 of the nucleotide sequences in (a), (b), (c), (d), (e), (f), (g), or (h), above.

The present invention encompasses polypeptide sequences which comprise, or alternatively consist of, an amino acid sequence which is at least about 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to, the following non-limited
30 examples, the polypeptide sequence identified as SEQ ID NO:2, the polypeptide sequence encoded by a cDNA provided in the deposited clone, and/or polypeptide fragments of any of the polypeptides provided herein. Polynucleotides encoded by these nucleic acid molecules are also encompassed by the invention. In another embodiment, the invention encompasses nucleic acid molecule which comprise, or
35 alternatively, consist of a polynucleotide which hybridizes under stringent conditions, or alternatively, under lower stringency conditions, to a polynucleotide in (a), (b), (c),

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5 (d), (e), (f), (g), or (h), above. Polynucleotides which hybridize to the complement of these nucleic acid molecules under stringent hybridization conditions or alternatively, under lower stringency conditions, are also encompassed by the invention, as are polypeptides encoded by these polypeptides.

The present invention is also directed to polypeptides which comprise, or
 10 alternatively consist of, an amino acid sequence which is at least about 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to, for example, the polypeptide sequence shown in SEQ ID NO:2, a polypeptide sequence encoded by the nucleotide sequence in SEQ ID NO:1, or SEQ ID NO:23, a polypeptide sequence
 15 encoded by the cDNA in cDNA plasmid:Z, and/or polypeptide fragments of any of these polypeptides (e.g., those fragments described herein). Polynucleotides which hybridize to the complement of the nucleic acid molecules encoding these polypeptides under stringent hybridization conditions or alternatively, under lower stringency conditions, are also encompassed by the present invention, as are the
 20 polypeptides encoded by these polynucleotides.

By a nucleic acid having a nucleotide sequence at least, for example, 95% "identical" to a reference nucleotide sequence of the present invention, it is intended that the nucleotide sequence of the nucleic acid is identical to the reference sequence except that the nucleotide sequence may include up to five point mutations per each
 25 100 nucleotides of the reference nucleotide sequence encoding the polypeptide. In other words, to obtain a nucleic acid having a nucleotide sequence at least 95% identical to a reference nucleotide sequence, up to 5% of the nucleotides in the reference sequence may be deleted or substituted with another nucleotide, or a number of nucleotides up to 5% of the total nucleotides in the reference sequence may
 30 be inserted into the reference sequence. The query sequence may be an entire sequence referenced in Table 1, the ORF (open reading frame), or any fragment specified as described herein.

As a practical matter, whether any particular nucleic acid molecule or polypeptide is at least about 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%,
 35 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to a nucleotide sequence of the present invention can be determined

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5 conventionally using known computer programs. A preferred method for determining the best overall match between a query sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, can be determined using the CLUSTALW computer program (Thompson, J.D., et al., Nucleic Acids Research, 2(22):4673-4680, (1994)), which is based on the algorithm
 10 of Higgins, D.G., et al., Computer Applications in the Biosciences (CABIOS), 8(2):189-191, (1992). In a sequence alignment the query and subject sequences are both DNA sequences. An RNA sequence can be compared by converting U's to T's. However, the CLUSTALW algorithm automatically converts U's to T's when comparing RNA sequences to DNA sequences. The result of said global sequence
 15 alignment is in percent identity. Preferred parameters used in a CLUSTALW alignment of DNA sequences to calculate percent identity via pairwise alignments are: Matrix=IUB, k-tuple=1, Number of Top Diagonals=5, Gap Penalty=3, Gap Open Penalty 10, Gap Extension Penalty=0.1, Scoring Method=Percent, Window Size=5 or the length of the subject nucleotide sequence, whichever is shorter. For multiple
 20 alignments, the following CLUSTALW parameters are preferred: Gap Opening Penalty=10; Gap Extension Parameter=0.05; Gap Separation Penalty Range=8; End Gap Separation Penalty=Off; % Identity for Alignment Delay=40%; Residue Specific Gaps:Off; Hydrophilic Residue Gap=Off; and Transition Weighting=0. The pairwise and multiple alignment parameters provided for CLUSTALW above represent the
 25 default parameters as provided with the AlignX software program (Vector NTI suite of programs, version 6.0).

The present invention encompasses the application of a manual correction to the percent identity results, in the instance where the subject sequence is shorter than the query sequence because of 5' or 3' deletions, not because of internal deletions. If
 30 only the local pairwise percent identity is required, no manual correction is needed. However, a manual correction may be applied to determine the global percent identity from a global polynucleotide alignment. Percent identity calculations based upon global polynucleotide alignments are often preferred since they reflect the percent identity between the polynucleotide molecules as a whole (i.e., including any
 35 polynucleotide overhangs, not just overlapping regions), as opposed to, only local matching polynucleotides. Manual corrections for global percent identity

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5 determinations are required since the CLUSTALW program does not account for 5' and 3' truncations of the subject sequence when calculating percent identity. For subject sequences truncated at the 5' or 3' ends, relative to the query sequence, the percent identity is corrected by calculating the number of bases of the query sequence that are 5' and 3' of the subject sequence, which are not matched/aligned, as a percent
10 of the total bases of the query sequence. Whether a nucleotide is matched/aligned is determined by results of the CLUSTALW sequence alignment. This percentage is then subtracted from the percent identity, calculated by the above CLUSTALW program using the specified parameters, to arrive at a final percent identity score. This corrected score may be used for the purposes of the present invention. Only bases
15 outside the 5' and 3' bases of the subject sequence, as displayed by the CLUSTALW alignment, which are not matched/aligned with the query sequence, are calculated for the purposes of manually adjusting the percent identity score.

For example, a 90 base subject sequence is aligned to a 100 base query sequence to determine percent identity. The deletions occur at the 5' end of the
20 subject sequence and therefore, the CLUSTALW alignment does not show a matched/alignment of the first 10 bases at 5' end. The 10 unpaired bases represent 10% of the sequence (number of bases at the 5' and 3' ends not matched/total number of bases in the query sequence) so 10% is subtracted from the percent identity score calculated by the CLUSTALW program. If the remaining 90 bases were perfectly
25 matched the final percent identity would be 90%. In another example, a 90 base subject sequence is compared with a 100 base query sequence. This time the deletions are internal deletions so that there are no bases on the 5' or 3' of the subject sequence which are not matched/aligned with the query. In this case the percent identity calculated by CLUSTALW is not manually corrected. Once again, only bases 5' and
30 3' of the subject sequence which are not matched/aligned with the query sequence are manually corrected for. No other manual corrections are required for the purposes of the present invention.

By a polypeptide having an amino acid sequence at least, for example, 95% "identical" to a query amino acid sequence of the present invention, it is intended that
35 the amino acid sequence of the subject polypeptide is identical to the query sequence except that the subject polypeptide sequence may include up to five amino acid

As a practical matter, whether any particular polypeptide is at least about 80%, 85%, 90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99%, 99.1%, 99.2%, 99.3%, 99.4%, 99.5%, 99.6%, 99.7%, 99.8%, or 99.9% identical to, for instance, an amino acid sequence referenced in Table 1 (SEQ ID NO:2, or SEQ ID NO:24) or to the amino acid sequence encoded by cDNA contained in a deposited clone, can be determined conventionally using known computer programs. A preferred method for determining the best overall match between a query sequence (a sequence of the present invention) and a subject sequence, also referred to as a global sequence alignment, can be determined using the CLUSTALW computer program (Thompson, J.D., et al., *Nucleic Acids Research*, 2(22):4673-4680, (1994)), which is based on the algorithm of Higgins, D.G., et al., *Computer Applications in the Biosciences (CABIOS)*, 8(2):189-191, (1992). In a sequence alignment the query and subject sequences are both amino acid sequences. The result of said global sequence alignment is in percent identity. Preferred parameters used in a CLUSTALW alignment of DNA sequences to calculate percent identity via pairwise alignments are: Matrix=BLOSUM, k-tuple=1, Number of Top Diagonals=5, Gap Penalty=3, Gap Open Penalty 10, Gap Extension Penalty=0.1, Scoring Method=Percent, Window Size=5 or the length of the subject nucleotide sequence, whichever is shorter. For multiple alignments, the following CLUSTALW parameters are preferred: Gap Opening Penalty=10; Gap Extension Parameter=0.05; Gap Separation Penalty Range=8; End Gap Separation Penalty=Off; % Identity for Alignment Delay=40%; Residue Specific Gaps:Off; Hydrophilic Residue Gap=Off; and Transition Weighting=0. The pairwise and multiple alignment parameters provided for

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5 CLUSTALW above represent the default parameters as provided with the AlignX software program (Vector NTI suite of programs, version 6.0).

The present invention encompasses the application of a manual correction to the percent identity results, in the instance where the subject sequence is shorter than the query sequence because of N- or C-terminal deletions, not because of internal
 10 deletions. If only the local pairwise percent identity is required, no manual correction is needed. However, a manual correction may be applied to determine the global percent identity from a global polypeptide alignment. Percent identity calculations based upon global polypeptide alignments are often preferred since they reflect the percent identity between the polypeptide molecules as a whole (i.e., including any
 15 polypeptide overhangs, not just overlapping regions), as opposed to, only local matching polypeptides. Manual corrections for global percent identity determinations are required since the CLUSTALW program does not account for N- and C-terminal truncations of the subject sequence when calculating percent identity. For subject sequences truncated at the N- and C-termini, relative to the query sequence, the
 20 percent identity is corrected by calculating the number of residues of the query sequence that are N- and C-terminal of the subject sequence, which are not matched/aligned with a corresponding subject residue, as a percent of the total bases of the query sequence. Whether a residue is matched/aligned is determined by results of the CLUSTALW sequence alignment. This percentage is then subtracted from the
 25 percent identity, calculated by the above CLUSTALW program using the specified parameters, to arrive at a final percent identity score. This final percent identity score is what may be used for the purposes of the present invention. Only residues to the N- and C-termini of the subject sequence, which are not matched/aligned with the query sequence, are considered for the purposes of manually adjusting the percent identity
 30 score. That is, only query residue positions outside the farthest N- and C-terminal residues of the subject sequence.

For example, a 90 amino acid residue subject sequence is aligned with a 100 residue query sequence to determine percent identity. The deletion occurs at the N-terminus of the subject sequence and therefore, the CLUSTALW alignment does not
 35 show a matching/alignment of the first 10 residues at the N-terminus. The 10 unpaired residues represent 10% of the sequence (number of residues at the N- and C- termini

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5 not matched/total number of residues in the query sequence) so 10% is subtracted from the percent identity score calculated by the CLUSTALW program. If the remaining 90 residues were perfectly matched the final percent identity would be 90%. In another example, a 90 residue subject sequence is compared with a 100 residue query sequence. This time the deletions are internal deletions so there are no
10 residues at the N- or C-termini of the subject sequence, which are not matched/aligned with the query. In this case the percent identity calculated by CLUSTALW is not manually corrected. Once again, only residue positions outside the N- and C-terminal ends of the subject sequence, as displayed in the CLUSTALW alignment, which are not matched/aligned with the query sequence are manually corrected for. No other
15 manual corrections are required for the purposes of the present invention.

In addition to the above method of aligning two or more polynucleotide or polypeptide sequences to arrive at a percent identity value for the aligned sequences, it may be desirable in some circumstances to use a modified version of the CLUSTALW algorithm which takes into account known structural features of the
20 sequences to be aligned, such as for example, the SWISS-PROT designations for each sequence. The result of such a modified CLUSTALW algorithm may provide a more accurate value of the percent identity for two polynucleotide or polypeptide sequences. Support for such a modified version of CLUSTALW is provided within the CLUSTALW algorithm and would be readily appreciated to one of skill in the art
25 of bioinformatics.

The variants may contain alterations in the coding regions, non-coding regions, or both. Especially preferred are polynucleotide variants containing alterations which produce silent substitutions, additions, or deletions, but do not alter the properties or activities of the encoded polypeptide. Nucleotide variants produced
30 by silent substitutions due to the degeneracy of the genetic code are preferred. Moreover, variants in which 5-10, 1-5, or 1-2 amino acids are substituted, deleted, or added in any combination are also preferred. Polynucleotide variants can be produced for a variety of reasons, e.g., to optimize codon expression for a particular host (change codons in the mRNA to those preferred by a bacterial host such as E. coli).

35 Naturally occurring variants are called "allelic variants," and refer to one of several alternate forms of a gene occupying a given locus on a chromosome of an

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5 organism. (Genes II, Lewin, B., ed., John Wiley & Sons, New York (1985).) These allelic variants can vary at either the polynucleotide and/or polypeptide level and are included in the present invention. Alternatively, non-naturally occurring variants may be produced by mutagenesis techniques or by direct synthesis.

Using known methods of protein engineering and recombinant DNA
10 technology, variants may be generated to improve or alter the characteristics of the polypeptides of the present invention. For instance, one or more amino acids can be deleted from the N-terminus or C-terminus of the protein without substantial loss of biological function. The authors of Ron et al., J. Biol. Chem... 268: 2984-2988 (1993), reported variant KGF proteins having heparin binding activity even after deleting 3, 8,
15 or 27 amino-terminal amino acid residues. Similarly, Interferon gamma exhibited up to ten times higher activity after deleting 8-10 amino acid residues from the carboxy terminus of this protein (Dobeli et al., J. Biotechnology 7:199-216 (1988)).

Moreover, ample evidence demonstrates that variants often retain a biological activity similar to that of the naturally occurring protein. For example, Gayle and
20 coworkers (J. Biol. Chem.. 268:22105-22111 (1993)) conducted extensive mutational analysis of human cytokine IL-1a. They used random mutagenesis to generate over 3,500 individual IL-1a mutants that averaged 2.5 amino acid changes per variant over the entire length of the molecule. Multiple mutations were examined at every possible amino acid position. The investigators found that "[m]ost of the molecule could be
25 altered with little effect on either [binding or biological activity]." In fact, only 23 unique amino acid sequences, out of more than 3,500 nucleotide sequences examined, produced a protein that significantly differed in activity from wild-type.

Furthermore, even if deleting one or more amino acids from the N-terminus or C-terminus of a polypeptide results in modification or loss of one or more biological
30 functions, other biological activities may still be retained. For example, the ability of a deletion variant to induce and/or to bind antibodies which recognize the protein will likely be retained when less than the majority of the residues of the protein are removed from the N-terminus or C-terminus. Whether a particular polypeptide lacking N- or C-terminal residues of a protein retains such immunogenic activities can
35 readily be determined by routine methods described herein and otherwise known in the art.

5 Alternatively, such N-terminus or C-terminus deletions of a polypeptide of the present invention may, in fact, result in a significant increase in one or more of the biological activities of the polypeptide(s). For example, biological activity of many polypeptides are governed by the presence of regulatory domains at either one or both termini. Such regulatory domains effectively inhibit the biological activity of such
10 polypeptides in lieu of an activation event (e.g., binding to a cognate ligand or receptor, phosphorylation, proteolytic processing, etc.). Thus, by eliminating the regulatory domain of a polypeptide, the polypeptide may effectively be rendered biologically active in the absence of an activation event.

 Thus, the invention further includes polypeptide variants that show substantial
15 biological activity. Such variants include deletions, insertions, inversions, repeats, and substitutions selected according to general rules known in the art so as have little effect on activity. For example, guidance concerning how to make phenotypically silent amino acid substitutions is provided in Bowie et al., Science 247:1306-1310 (1990), wherein the authors indicate that there are two main strategies for studying the
20 tolerance of an amino acid sequence to change.

 The first strategy exploits the tolerance of amino acid substitutions by natural selection during the process of evolution. By comparing amino acid sequences in different species, conserved amino acids can be identified. These conserved amino acids are likely important for protein function. In contrast, the amino acid positions
25 where substitutions have been tolerated by natural selection indicates that these positions are not critical for protein function. Thus, positions tolerating amino acid substitution could be modified while still maintaining biological activity of the protein.

 The second strategy uses genetic engineering to introduce amino acid changes
30 at specific positions of a cloned gene to identify regions critical for protein function. For example, site directed mutagenesis or alanine-scanning mutagenesis (introduction of single alanine mutations at every residue in the molecule) can be used. (Cunningham and Wells, Science 244:1081-1085 (1989).) The resulting mutant molecules can then be tested for biological activity.

35 As the authors state, these two strategies have revealed that proteins are surprisingly tolerant of amino acid substitutions. The authors further indicate which

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5 amino acid changes are likely to be permissive at certain amino acid positions in the protein. For example, most buried (within the tertiary structure of the protein) amino acid residues require nonpolar side chains, whereas few features of surface side chains are generally conserved.

The invention encompasses polypeptides having a lower degree of identity but
10 having sufficient similarity so as to perform one or more of the same functions performed by the polypeptide of the present invention. Similarity is determined by conserved amino acid substitution. Such substitutions are those that substitute a given amino acid in a polypeptide by another amino acid of like characteristics (e.g., chemical properties). According to Cunningham et al above, such conservative
15 substitutions are likely to be phenotypically silent. Additional guidance concerning which amino acid changes are likely to be phenotypically silent are found in Bowie et al., Science 247:1306-1310 (1990).

Tolerated conservative amino acid substitutions of the present invention involve replacement of the aliphatic or hydrophobic amino acids Ala, Val, Leu and
20 Ile; replacement of the hydroxyl residues Ser and Thr; replacement of the acidic residues Asp and Glu; replacement of the amide residues Asn and Gln, replacement of the basic residues Lys, Arg, and His; replacement of the aromatic residues Phe, Tyr, and Trp, and replacement of the small-sized amino acids Ala, Ser, Thr, Met, and Gly.

In addition, the present invention also encompasses the conservative
25 substitutions provided in Table III below.

Table III

For Amino Acid	Code	Replace with any of:
Alanine	A	D-Ala, Gly, beta-Ala, L-Cys, D-Cys
Arginine	R	D-Arg, Lys, D-Lys, homo-Arg, D-homo-Arg, Met, Ile, D-Met, D-Ile, Orn, D-Orn
Asparagine	N	D-Asn, Asp, D-Asp, Glu, D-Glu, Gln, D-Gln
Aspartic Acid	D	D-Asp, D-Asn, Asn, Glu, D-Glu, Gln, D-Gln
Cysteine	C	D-Cys, S-Me-Cys, Met, D-Met, Thr, D-Thr
Glutamine	Q	D-Gln, Asn, D-Asn, Glu, D-Glu, Asp, D-Asp
Glutamic Acid	E	D-Glu, D-Asp, Asp, Asn, D-Asn, Gln, D-Gln
Glycine	G	Ala, D-Ala, Pro, D-Pro, β -Ala, Acp
Isoleucine	I	D-Ile, Val, D-Val, Leu, D-Leu, Met, D-Met
Leucine	L	D-Leu, Val, D-Val, Met, D-Met
Lysine	K	D-Lys, Arg, D-Arg, homo-Arg, D-homo-Arg, Met, D-Met, Ile, D-Ile, Orn, D-Orn
Methionine	M	D-Met, S-Me-Cys, Ile, D-Ile, Leu, D-Leu, Val, D-Val
Phenylalanine	F	D-Phe, Tyr, D-Thr, L-Dopa, His, D-His, Trp, D-Trp, Trans-3,4, or 5-phenylproline, cis-3,4, or 5-phenylproline

For Amino Acid	Code	Replace with any of:
Proline	P	D-Pro, L-1-thioazolidine-4-carboxylic acid, D- or L-1-oxazolidine-4-carboxylic acid
Serine	S	D-Ser, Thr, D-Thr, allo-Thr, Met, D-Met, Met(O), D-Met(O), L-Cys, D-Cys
Threonine	T	D-Thr, Ser, D-Ser, allo-Thr, Met, D-Met, Met(O), D-Met(O), Val, D-Val
Tyrosine	Y	D-Tyr, Phe, D-Phe, L-Dopa, His, D-His
Valine	V	D-Val, Leu, D-Leu, Ile, D-Ile, Met, D-Met

5

Aside from the uses described above, such amino acid substitutions may also increase protein or peptide stability. The invention encompasses amino acid substitutions that contain, for example, one or more non-peptide bonds (which replace the peptide bonds) in the protein or peptide sequence. Also included are substitutions that include amino acid residues other than naturally occurring L-amino acids, e.g., D-amino acids or non-naturally occurring or synthetic amino acids, e.g., β or γ amino acids.

Both identity and similarity can be readily calculated by reference to the following publications: Computational Molecular Biology, Lesk, A.M., ed., Oxford University Press, New York, 1988; Biocomputing: Informatics and Genome Projects, Smith, D.W., ed., Academic Press, New York, 1993; Informatics Computer Analysis of Sequence Data, Part 1, Griffin, A.M., and Griffin, H.G., eds., Humana Press, New Jersey, 1994; Sequence Analysis in Molecular Biology, von Heinje, G., Academic Press, 1987; and Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M Stockton Press, New York, 1991.

In addition, the present invention also encompasses substitution of amino acids based upon the probability of an amino acid substitution resulting in conservation of function. Such probabilities are determined by aligning multiple genes with related function and assessing the relative penalty of each substitution to proper gene function. Such probabilities are often described in a matrix and are used by some algorithms (e.g., BLAST, CLUSTALW, GAP, etc.) in calculating percent similarity wherein similarity refers to the degree by which one amino acid may substitute for another amino acid without lose of function. An example of such a matrix is the PAM250 or BLOSUM62 matrix.

Aside from the canonical chemically conservative substitutions referenced above, the invention also encompasses substitutions which are typically not classified

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5 as conservative, but that may be chemically conservative under certain circumstances. Analysis of enzymatic catalysis for proteases, for example, has shown that certain amino acids within the active site of some enzymes may have highly perturbed pKa's due to the unique microenvironment of the active site. Such perturbed pKa's could enable some amino acids to substitute for other amino acids while conserving
10 enzymatic structure and function. Examples of amino acids that are known to have amino acids with perturbed pKa's are the Glu-35 residue of Lysozyme, the Ile-16 residue of Chymotrypsin, the His-159 residue of Papain, etc. The conservation of function relates to either anomalous protonation or anomalous deprotonation of such amino acids, relative to their canonical, non-perturbed pKa. The pKa perturbation
15 may enable these amino acids to actively participate in general acid-base catalysis due to the unique ionization environment within the enzyme active site. Thus, substituting an amino acid capable of serving as either a general acid or general base within the microenvironment of an enzyme active site or cavity, as may be the case, in the same or similar capacity as the wild-type amino acid, would effectively serve as a
20 conservative amino substitution.

Besides conservative amino acid substitution, variants of the present invention include, but are not limited to, the following: (i) substitutions with one or more of the non-conserved amino acid residues, where the substituted amino acid residues may or may not be one encoded by the genetic code, or (ii) substitution with one or more of
25 amino acid residues having a substituent group, or (iii) fusion of the mature polypeptide with another compound, such as a compound to increase the stability and/or solubility of the polypeptide (for example, polyethylene glycol), or (iv) fusion of the polypeptide with additional amino acids, such as, for example, an IgG Fc fusion region peptide, or leader or secretory sequence, or a sequence facilitating purification.
30 Such variant polypeptides are deemed to be within the scope of those skilled in the art from the teachings herein.

For example, polypeptide variants containing amino acid substitutions of charged amino acids with other charged or neutral amino acids may produce proteins with improved characteristics, such as less aggregation. Aggregation of
35 pharmaceutical formulations both reduces activity and increases clearance due to the aggregate's immunogenic activity. (Pinckard et al., Clin. Exp. Immunol. 2:331-340

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- 5 (1967); Robbins et al., Diabetes 36: 838-845 (1987); Cleland et al., Crit. Rev. Therapeutic Drug Carrier Systems 10:307-377 (1993).)

Moreover, the invention further includes polypeptide variants created through the application of molecular evolution ("DNA Shuffling") methodology to the polynucleotide disclosed as SEQ ID NO:1, or SEQ ID NO:23, the sequence of the
10 clone submitted in a deposit, and/or the cDNA encoding the polypeptide disclosed as SEQ ID NO:2, or SEQ ID NO:24. Such DNA Shuffling technology is known in the art and more particularly described elsewhere herein (e.g., WPC, Stemmer, PNAS, 91:10747, (1994)), and in the Examples provided herein).

A further embodiment of the invention relates to a polypeptide which
15 comprises the amino acid sequence of the present invention having an amino acid sequence which contains at least one amino acid substitution, but not more than 50 amino acid substitutions, even more preferably, not more than 40 amino acid substitutions, still more preferably, not more than 30 amino acid substitutions, and still even more preferably, not more than 20 amino acid substitutions. Of course, in
20 order of ever-increasing preference, it is highly preferable for a peptide or polypeptide to have an amino acid sequence which comprises the amino acid sequence of the present invention, which contains at least one, but not more than 10, 9, 8, 7, 6, 5, 4, 3, 2 or 1 amino acid substitutions. In specific embodiments, the number of additions, substitutions, and/or deletions in the amino acid sequence of the present invention or
25 fragments thereof (e.g., the mature form and/or other fragments described herein), is 1-5, 5-10, 5-25, 5-50, 10-50 or 50-150, conservative amino acid substitutions are preferable.

Polynucleotide and Polypeptide Fragments

30 The present invention is directed to polynucleotide fragments of the polynucleotides of the invention, in addition to polypeptides encoded therein by said polynucleotides and/or fragments.

In the present invention, a "polynucleotide fragment" refers to a short polynucleotide having a nucleic acid sequence which: is a portion of that contained in
35 a deposited clone, or encoding the polypeptide encoded by the cDNA in a deposited clone; is a portion of that shown in SEQ ID NO:1, or SEQ ID NO:23, or the

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5 complementary strand thereto, or is a portion of a polynucleotide sequence encoding the polypeptide of SEQ ID NO:2, or SEQ ID NO:24. The nucleotide fragments of the invention are preferably at least about 15 nt, and more preferably at least about 20 nt, still more preferably at least about 30 nt, and even more preferably, at least about 40 nt, at least about 50 nt, at least about 75 nt, or at least about 150 nt in length. A
10 fragment "at least 20 nt in length," for example, is intended to include 20 or more contiguous bases from the cDNA sequence contained in a deposited clone or the nucleotide sequence shown in SEQ ID NO:1, or SEQ ID NO:23. In this context "about" includes the particularly recited value, a value larger or smaller by several (5, 4, 3, 2, or 1) nucleotides, at either terminus, or at both termini. These nucleotide
15 fragments have uses that include, but are not limited to, as diagnostic probes and primers as discussed herein. Of course, larger fragments (e.g., 50, 150, 500, 600, 2000 nucleotides) are preferred.

Moreover, representative examples of polynucleotide fragments of the invention, include, for example, fragments comprising, or alternatively consisting of,
20 a sequence from about nucleotide number 1-50, 51-100, 101-150, 151-200, 201-250, 251-300, 301-350, 351-400, 401-450, 451-500, 501-550, 551-600, 651-700, 701-750, 751-800, 800-850, 851-900, 901-950, 951-1000, 1001-1050, 1051-1100, 1101-1150, 1151-1200, 1201-1250, 1251-1300, 1301-1350, 1351-1400, 1401-1450, 1451-1500, 1501-1550, 1551-1600, 1601-1650, 1651-1700, 1701-1750, 1751-1800, 1801-1850,
25 1851-1900, 1901-1950, 1951-2000, or 2001 to the end of SEQ ID NO:1, or SEQ ID NO:23, or the complementary strand thereto, or the cDNA contained in a deposited clone. In this context "about" includes the particularly recited ranges, and ranges larger or smaller by several (5, 4, 3, 2, or 1) nucleotides, at either terminus or at both termini. Preferably, these fragments encode a polypeptide which has biological
30 activity. More preferably, these polynucleotides can be used as probes or primers as discussed herein. Also encompassed by the present invention are polynucleotides which hybridize to these nucleic acid molecules under stringent hybridization conditions or lower stringency conditions, as are the polypeptides encoded by these polynucleotides.

35 In the present invention, a "polypeptide fragment" refers to an amino acid sequence which is a portion of that contained in SEQ ID NO:2, or SEQ ID NO:24, or

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5 encoded by the cDNA contained in a deposited clone. Protein (polypeptide) fragments
 may be "free-standing," or comprised within a larger polypeptide of which the
 fragment forms a part or region, most preferably as a single continuous region.
 Representative examples of polypeptide fragments of the invention, include, for
 example, fragments comprising, or alternatively consisting of, from about amino acid
 10 number 1-20, 21-40, 41-60, 61-80, 81-100, 102-120, 121-140, 141-160, or 161 to the
 end of the coding region. Moreover, polypeptide fragments can be about 20, 30, 40,
 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, or 150 amino acids in length. In this
 context "about" includes the particularly recited ranges or values, and ranges or values
 larger or smaller by several (5, 4, 3, 2, or 1) amino acids, at either extreme or at both
 15 extremes. Polynucleotides encoding these polypeptides are also encompassed by the
 invention.

Preferred polypeptide fragments include the full-length protein. Further
 preferred polypeptide fragments include the full-length protein having a continuous
 series of deleted residues from the amino or the carboxy terminus, or both. For
 20 example, any number of amino acids, ranging from 1-60, can be deleted from the
 amino terminus of the full-length polypeptide. Similarly, any number of amino acids,
 ranging from 1-30, can be deleted from the carboxy terminus of the full-length
 protein. Furthermore, any combination of the above amino and carboxy terminus
 deletions are preferred. Similarly, polynucleotides encoding these polypeptide
 25 fragments are also preferred.

Also preferred are polypeptide and polynucleotide fragments characterized by
 structural or functional domains, such as fragments that comprise alpha-helix and
 alpha-helix forming regions, beta-sheet and beta-sheet-forming regions, turn and turn-
 forming regions, coil and coil-forming regions, hydrophilic regions, hydrophobic
 30 regions, alpha amphipathic regions, beta amphipathic regions, flexible regions,
 surface-forming regions, substrate binding region, and high antigenic index regions.
 Polypeptide fragments of SEQ ID NO:2, or SEQ ID NO:24, falling within conserved
 domains are specifically contemplated by the present invention. Moreover,
 polynucleotides encoding these domains are also contemplated.

35 Other preferred polypeptide fragments are biologically active fragments.
 Biologically active fragments are those exhibiting activity similar, but not necessarily

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5 identical, to an activity of the polypeptide of the present invention. The biological activity of the fragments may include an improved desired activity, or a decreased undesirable activity. Polynucleotides encoding these polypeptide fragments are also encompassed by the invention.

10 In a preferred embodiment, the functional activity displayed by a polypeptide encoded by a polynucleotide fragment of the invention may be one or more biological activities typically associated with the full-length polypeptide of the invention. Illustrative of these biological activities includes the fragments ability to bind to at least one of the same antibodies which bind to the full-length protein, the fragments ability to interact with at least one of the same proteins which bind to the full-length, 15 the fragments ability to elicit at least one of the same immune responses as the full-length protein (i.e., to cause the immune system to create antibodies specific to the same epitope, etc.), the fragments ability to bind to at least one of the same polynucleotides as the full-length protein, the fragments ability to bind to a receptor of the full-length protein, the fragments ability to bind to a ligand of the full-length 20 protein, and the fragments ability to multimerize with the full-length protein. However, the skilled artisan would appreciate that some fragments may have biological activities which are desirable and directly inapposite to the biological activity of the full-length protein. The functional activity of polypeptides of the invention, including fragments, variants, derivatives, and analogs thereof can be 25 determined by numerous methods available to the skilled artisan, some of which are described elsewhere herein.

The present invention encompasses polypeptides comprising, or alternatively consisting of, an epitope of the polypeptide having an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, or an epitope of the polypeptide sequence encoded by a 30 polynucleotide sequence contained in ATCC deposit No. Z or encoded by a polynucleotide that hybridizes to the complement of the sequence of SEQ ID NO:1, or SEQ ID NO:23, or contained in ATCC deposit No. Z under stringent hybridization conditions or lower stringency hybridization conditions as defined supra. The present invention further encompasses polynucleotide sequences encoding an epitope of a 35 polypeptide sequence of the invention (such as, for example, the sequence disclosed in SEQ ID NO:1, or SEQ ID NO:23), polynucleotide sequences of the complementary

5 strand of a polynucleotide sequence encoding an epitope of the invention, and polynucleotide sequences which hybridize to the complementary strand under stringent hybridization conditions or lower stringency hybridization conditions defined supra.

The term "epitopes," as used herein, refers to portions of a polypeptide having
10 antigenic or immunogenic activity in an animal, preferably a mammal, and most preferably in a human. In a preferred embodiment, the present invention encompasses a polypeptide comprising an epitope, as well as the polynucleotide encoding this polypeptide. An "immunogenic epitope," as used herein, is defined as a portion of a protein that elicits an antibody response in an animal, as determined by any method
15 known in the art, for example, by the methods for generating antibodies described infra. (See, for example, Geysen et al., Proc. Natl. Acad. Sci. USA 81:3998- 4002 (1983)). The term "antigenic epitope," as used herein, is defined as a portion of a protein to which an antibody can immunospecifically bind its antigen as determined by any method well known in the art, for example, by the immunoassays described
20 herein. Immunospecific binding excludes non-specific binding but does not necessarily exclude cross- reactivity with other antigens. Antigenic epitopes need not necessarily be immunogenic.

Fragments which function as epitopes may be produced by any conventional means. (See, e.g., Houghten, Proc. Natl. Acad. Sci. USA 82:5131-5135 (1985),
25 further described in U.S. Patent No. 4,631,211).

In the present invention, antigenic epitopes preferably contain a sequence of at least 4, at least 5, at least 6, at least 7, more preferably at least 8, at least 9, at least 10, at least 11, at least 12, at least 13, at least 14, at least 15, at least 20, at least 25, at least 30, at least 40, at least 50, and, most preferably, between about 15 to about 30
30 amino acids. Preferred polypeptides comprising immunogenic or antigenic epitopes are at least 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, or 100 amino acid residues in length, or longer. Additional non-exclusive preferred antigenic epitopes include the antigenic epitopes disclosed herein, as well as portions thereof. Antigenic epitopes are useful, for example, to raise antibodies, including monoclonal
35 antibodies, that specifically bind the epitope. Preferred antigenic epitopes include the antigenic epitopes disclosed herein, as well as any combination of two, three, four,

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5 five or more of these antigenic epitopes. Antigenic epitopes can be used as the target molecules in immunoassays. (See, for instance, Wilson et al., Cell 37:767-778 (1984); Sutcliffe et al., Science 219:660-666 (1983)).

Similarly, immunogenic epitopes can be used, for example, to induce antibodies according to methods well known in the art. (See, for instance, Sutcliffe et
10 al., supra; Wilson et al., supra; Chow et al., Proc. Natl. Acad. Sci. USA 82:910-914; and Bittle et al., J. Gen. Virol. 66:2347-2354 (1985). Preferred immunogenic epitopes include the immunogenic epitopes disclosed herein, as well as any combination of two, three, four, five or more of these immunogenic epitopes. The polypeptides comprising one or more immunogenic epitopes may be presented for eliciting an
15 antibody response together with a carrier protein, such as an albumin, to an animal system (such as rabbit or mouse), or, if the polypeptide is of sufficient length (at least about 25 amino acids), the polypeptide may be presented without a carrier. However, immunogenic epitopes comprising as few as 8 to 10 amino acids have been shown to be sufficient to raise antibodies capable of binding to, at the very least, linear epitopes
20 in a denatured polypeptide (e.g., in Western blotting).

Epitope-bearing polypeptides of the present invention may be used to induce antibodies according to methods well known in the art including, but not limited to, in vivo immunization, in vitro immunization, and phage display methods. See, e.g., Sutcliffe et al., supra; Wilson et al., supra, and Bittle et al., J. Gen. Virol., 66:2347-
25 2354 (1985). If in vivo immunization is used, animals may be immunized with free peptide; however, anti-peptide antibody titer may be boosted by coupling the peptide to a macromolecular carrier, such as keyhole limpet hemacyanin (KLH) or tetanus toxoid. For instance, peptides containing cysteine residues may be coupled to a carrier using a linker such as maleimidobenzoyl- N-hydroxysuccinimide ester (MBS), while
30 other peptides may be coupled to carriers using a more general linking agent such as glutaraldehyde. Animals such as rabbits, rats and mice are immunized with either free or carrier- coupled peptides, for instance, by intraperitoneal and/or intradermal injection of emulsions containing about 100 µg of peptide or carrier protein and Freund's adjuvant or any other adjuvant known for stimulating an immune response.
35 Several booster injections may be needed, for instance, at intervals of about two weeks, to provide a useful titer of anti-peptide antibody which can be detected, for

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5 example, by ELISA assay using free peptide adsorbed to a solid surface. The titer of anti-peptide antibodies in serum from an immunized animal may be increased by selection of anti-peptide antibodies, for instance, by adsorption to the peptide on a solid support and elution of the selected antibodies according to methods well known in the art.

10 As one of skill in the art will appreciate, and as discussed above, the polypeptides of the present invention comprising an immunogenic or antigenic epitope can be fused to other polypeptide sequences. For example, the polypeptides of the present invention may be fused with the constant domain of immunoglobulins (IgA, IgE, IgG, IgM), or portions thereof (CH1, CH2, CH3, or any combination
15 thereof and portions thereof) resulting in chimeric polypeptides. Such fusion proteins may facilitate purification and may increase half-life in vivo. This has been shown for chimeric proteins consisting of the first two domains of the human CD4-polypeptide and various domains of the constant regions of the heavy or light chains of mammalian immunoglobulins. See, e.g., EP 394,827; Traunecker et al., Nature,
20 331:84-86 (1988). Enhanced delivery of an antigen across the epithelial barrier to the immune system has been demonstrated for antigens (e.g., insulin) conjugated to an FcRn binding partner such as IgG or Fc fragments (see, e.g., PCT Publications WO 96/22024 and WO 99/04813). IgG Fusion proteins that have a disulfide-linked dimeric structure due to the IgG portion disulfide bonds have also been found to be
25 more efficient in binding and neutralizing other molecules than monomeric polypeptides or fragments thereof alone. See, e.g., Fountoulakis et al., J. Biochem., 270:3958-3964 (1995). Nucleic acids encoding the above epitopes can also be recombined with a gene of interest as an epitope tag (e.g., the hemagglutinin ("HA") tag or flag tag) to aid in detection and purification of the expressed polypeptide. For
30 example, a system described by Janknecht et al. allows for the ready purification of non-denatured fusion proteins expressed in human cell lines (Janknecht et al., 1991, Proc. Natl. Acad. Sci. USA 88:8972- 897). In this system, the gene of interest is subcloned into a vaccinia recombination plasmid such that the open reading frame of the gene is translationally fused to an amino-terminal tag consisting of six histidine
35 residues. The tag serves as a matrix binding domain for the fusion protein. Extracts from cells infected with the recombinant vaccinia virus are loaded onto Ni²⁺

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5 nitriloacetic acid-agarose column and histidine-tagged proteins can be selectively eluted with imidazole-containing buffers.

Additional fusion proteins of the invention may be generated through the techniques of gene-shuffling, motif-shuffling, exon-shuffling, and/or codon-shuffling (collectively referred to as "DNA shuffling"). DNA shuffling may be employed to
 10 modulate the activities of polypeptides of the invention, such methods can be used to generate polypeptides with altered activity, as well as agonists and antagonists of the polypeptides. See, generally, U.S. Patent Nos. 5,605,793; 5,811,238; 5,830,721; 5,834,252; and 5,837,458, and Patten et al., Curr. Opinion Biotechnol. 8:724-33 (1997); Harayama, Trends Biotechnol. 16(2):76-82 (1998); Hansson, et al., J. Mol.
 15 Biol. 287:265-76 (1999); and Lorenzo and Blasco, Biotechniques 24(2):308- 13 (1998) (each of these patents and publications are hereby incorporated by reference in its entirety). In one embodiment, alteration of polynucleotides corresponding to SEQ ID NO:1, or SEQ ID NO:23, and the polypeptides encoded by these polynucleotides may be achieved by DNA shuffling. DNA shuffling involves the assembly of two or
 20 more DNA segments by homologous or site-specific recombination to generate variation in the polynucleotide sequence. In another embodiment, polynucleotides of the invention, or the encoded polypeptides, may be altered by being subjected to random mutagenesis by error-prone PCR, random nucleotide insertion or other methods prior to recombination. In another embodiment, one or more components,
 25 motifs, sections, parts, domains, fragments, etc., of a polynucleotide encoding a polypeptide of the invention may be recombined with one or more components, motifs, sections, parts, domains, fragments, etc. of one or more heterologous molecules.

30 *Antibodies*

Further polypeptides of the invention relate to antibodies and T-cell antigen receptors (TCR) which immunospecifically bind a polypeptide, polypeptide fragment, or variant of SEQ ID NO:2, or SEQ ID NO:24, and/or an epitope, of the present invention (as determined by immunoassays well known in the art for assaying specific
 35 antibody-antigen binding). Antibodies of the invention include, but are not limited to, polyclonal, monoclonal, monovalent, bispecific, heteroconjugate, multispecific,

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5 human, humanized or chimeric antibodies, single chain antibodies, Fab fragments, F(ab') fragments, fragments produced by a Fab expression library, anti-idiotypic (anti-Id) antibodies (including, e.g., anti-Id antibodies to antibodies of the invention), and epitope-binding fragments of any of the above. The term "antibody," as used herein, refers to immunoglobulin molecules and immunologically active portions of
10 immunoglobulin molecules, i.e., molecules that contain an antigen binding site that immunospecifically binds an antigen. The immunoglobulin molecules of the invention can be of any type (e.g., IgG, IgE, IgM, IgD, IgA and IgY), class (e.g., IgG1, IgG2, IgG3, IgG4, IgA1 and IgA2) or subclass of immunoglobulin molecule. Moreover, the term "antibody" (Ab) or "monoclonal antibody" (Mab) is meant to include intact
15 molecules, as well as, antibody fragments (such as, for example, Fab and F(ab')₂ fragments) which are capable of specifically binding to protein. Fab and F(ab')₂ fragments lack the Fc fragment of intact antibody, clear more rapidly from the circulation of the animal or plant, and may have less non-specific tissue binding than an intact antibody (Wahl et al., J. Nucl. Med.. 24:316-325 (1983)). Thus, these
20 fragments are preferred, as well as the products of a FAB or other immunoglobulin expression library. Moreover, antibodies of the present invention include chimeric, single chain, and humanized antibodies.

Most preferably the antibodies are human antigen-binding antibody fragments of the present invention and include, but are not limited to, Fab, Fab' and F(ab')₂, Fd,
25 single-chain Fvs (scFv), single-chain antibodies, disulfide-linked Fvs (sdFv) and fragments comprising either a VL or VH domain. Antigen-binding antibody fragments, including single-chain antibodies, may comprise the variable region(s) alone or in combination with the entirety or a portion of the following: hinge region, CH1, CH2, and CH3 domains. Also included in the invention are antigen-binding
30 fragments also comprising any combination of variable region(s) with a hinge region, CH1, CH2, and CH3 domains. The antibodies of the invention may be from any animal origin including birds and mammals. Preferably, the antibodies are human, murine (e.g., mouse and rat), donkey, sheep rabbit, goat, guinea pig, camel, horse, or chicken. As used herein, "human" antibodies include antibodies having the amino
35 acid sequence of a human immunoglobulin and include antibodies isolated from human immunoglobulin libraries or from animals transgenic for one or more human

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5 immunoglobulin and that do not express endogenous immunoglobulins, as described infra and, for example in, U.S. Patent No. 5,939,598 by Kucherlapati et al.

The antibodies of the present invention may be monospecific, bispecific, trispecific or of greater multispecificity. Multispecific antibodies may be specific for different epitopes of a polypeptide of the present invention or may be specific for both
10 a polypeptide of the present invention as well as for a heterologous epitope, such as a heterologous polypeptide or solid support material. See, e.g., PCT publications WO 93/17715; WO 92/08802; WO 91/00360; WO 92/05793; Tutt, et al., J. Immunol. 147:60-69 (1991); U.S. Patent Nos. 4,474,893; 4,714,681; 4,925,648; 5,573,920; 5,601,819; Kostelny et al., J. Immunol. 148:1547-1553 (1992).

15 Antibodies of the present invention may be described or specified in terms of the epitope(s) or portion(s) of a polypeptide of the present invention which they recognize or specifically bind. The epitope(s) or polypeptide portion(s) may be specified as described herein, e.g., by N-terminal and C-terminal positions, by size in contiguous amino acid residues, or listed in the Tables and Figures. Antibodies which
20 specifically bind any epitope or polypeptide of the present invention may also be excluded. Therefore, the present invention includes antibodies that specifically bind polypeptides of the present invention, and allows for the exclusion of the same.

Antibodies of the present invention may also be described or specified in terms of their cross-reactivity. Antibodies that do not bind any other analog, ortholog,
25 or homologue of a polypeptide of the present invention are included. Antibodies that bind polypeptides with at least 95%, at least 90%, at least 85%, at least 80%, at least 75%, at least 70%, at least 65%, at least 60%, at least 55%, and at least 50% identity (as calculated using methods known in the art and described herein) to a polypeptide of the present invention are also included in the present invention. In specific
30 embodiments, antibodies of the present invention cross-react with murine, rat and/or rabbit homologues of human proteins and the corresponding epitopes thereof. Antibodies that do not bind polypeptides with less than 95%, less than 90%, less than 85%, less than 80%, less than 75%, less than 70%, less than 65%, less than 60%, less than 55%, and less than 50% identity (as calculated using methods known in the art and described herein) to a polypeptide of the present invention are also included in the
35 present invention. In a specific embodiment, the above-described cross-reactivity is

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5 with respect to any single specific antigenic or immunogenic polypeptide, or combination(s) of 2, 3, 4, 5, or more of the specific antigenic and/or immunogenic polypeptides disclosed herein. Further included in the present invention are antibodies which bind polypeptides encoded by polynucleotides which hybridize to a polynucleotide of the present invention under stringent hybridization conditions (as
10 described herein). Antibodies of the present invention may also be described or specified in terms of their binding affinity to a polypeptide of the invention. Preferred binding affinities include those with a dissociation constant or K_d less than 5×10^{-2} M, 10^{-2} M, 5×10^{-3} M, 10^{-3} M, 5×10^{-4} M, 10^{-4} M, 5×10^{-5} M, 10^{-5} M, 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M,
15 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, or 10^{-15} M.

The invention also provides antibodies that competitively inhibit binding of an antibody to an epitope of the invention as determined by any method known in the art for determining competitive binding, for example, the immunoassays described
20 herein. In preferred embodiments, the antibody competitively inhibits binding to the epitope by at least 95%, at least 90%, at least 85 %, at least 80%, at least 75%, at least 70%, at least 60%, or at least 50%.

Antibodies of the present invention may act as agonists or antagonists of the polypeptides of the present invention. For example, the present invention includes
25 antibodies which disrupt the receptor/ligand interactions with the polypeptides of the invention either partially or fully. Preferably, antibodies of the present invention bind an antigenic epitope disclosed herein, or a portion thereof. The invention features both receptor-specific antibodies and ligand-specific antibodies. The invention also features receptor-specific antibodies which do not prevent ligand binding but prevent
30 receptor activation. Receptor activation (i.e., signaling) may be determined by techniques described herein or otherwise known in the art. For example, receptor activation can be determined by detecting the phosphorylation (e.g., tyrosine or serine/threonine) of the receptor or its substrate by immunoprecipitation followed by western blot analysis (for example, as described supra). In specific embodiments,
35 antibodies are provided that inhibit ligand activity or receptor activity by at least 95%, at least 90%, at least 85%, at least 80%, at least 75%, at least 70%, at least 60%, or at

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5 least 50% of the activity in absence of the antibody.

The invention also features receptor-specific antibodies which both prevent ligand binding and receptor activation as well as antibodies that recognize the receptor-ligand complex, and, preferably, do not specifically recognize the unbound receptor or the unbound ligand. Likewise, included in the invention are neutralizing
10 antibodies which bind the ligand and prevent binding of the ligand to the receptor, as well as antibodies which bind the ligand, thereby preventing receptor activation, but do not prevent the ligand from binding the receptor. Further included in the invention are antibodies which activate the receptor. These antibodies may act as receptor agonists, i.e., potentiate or activate either all or a subset of the biological activities of
15 the ligand-mediated receptor activation, for example, by inducing dimerization of the receptor. The antibodies may be specified as agonists, antagonists or inverse agonists for biological activities comprising the specific biological activities of the peptides of the invention disclosed herein. The above antibody agonists can be made using methods known in the art. See, e.g., PCT publication WO 96/40281; U.S. Patent No.
20 5,811,097; Deng et al., Blood 92(6):1981-1988 (1998); Chen et al., Cancer Res. 58(16):3668-3678 (1998); Harrop et al., J. Immunol. 161(4):1786-1794 (1998); Zhu et al., Cancer Res. 58(15):3209-3214 (1998); Yoon et al., J. Immunol. 160(7):3170-3179 (1998); Prat et al., J. Cell. Sci. 111(Pt2):237-247 (1998); Pitard et al., J. Immunol. Methods 205(2):177-190 (1997); Liautard et al., Cytokine 9(4):233-241 (1997);
25 Carlson et al., J. Biol. Chem... 272(17):11295-11301 (1997); Taryman et al., Neuron 14(4):755-762 (1995); Muller et al., Structure 6(9):1153-1167 (1998); Bartunek et al., Cytokine 8(1):14-20 (1996) (which are all incorporated by reference herein in their entireties).

Antibodies of the present invention may be used, for example, but not limited
30 to, to purify, detect, and target the polypeptides of the present invention, including both in vitro and in vivo diagnostic and therapeutic methods. For example, the antibodies have use in immunoassays for qualitatively and quantitatively measuring levels of the polypeptides of the present invention in biological samples. See, e.g., Harlow et al., Antibodies: A Laboratory Manual, (Cold Spring Harbor Laboratory
35 Press, 2nd ed. 1988) (incorporated by reference herein in its entirety).

As discussed in more detail below, the antibodies of the present invention may

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5 be used either alone or in combination with other compositions. The antibodies may further be recombinantly fused to a heterologous polypeptide at the N- or C-terminus or chemically conjugated (including covalently and non-covalently conjugations) to polypeptides or other compositions. For example, antibodies of the present invention may be recombinantly fused or conjugated to molecules useful as labels in detection
10 assays and effector molecules such as heterologous polypeptides, drugs, radionucleotides, or toxins. See, e.g., PCT publications WO 92/08495; WO 91/14438; WO 89/12624; U.S. Patent No. 5,314,995; and EP 396,387.

The antibodies of the invention include derivatives that are modified, i.e., by the covalent attachment of any type of molecule to the antibody such that covalent
15 attachment does not prevent the antibody from generating an anti-idiotypic response. For example, but not by way of limitation, the antibody derivatives include antibodies that have been modified, e.g., by glycosylation, acetylation, pegylation, phosphorylation, amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to a cellular ligand or other protein, etc. Any of
20 numerous chemical modifications may be carried out by known techniques, including, but not limited to specific chemical cleavage, acetylation, formylation, metabolic synthesis of tunicamycin, etc. Additionally, the derivative may contain one or more non-classical amino acids.

The antibodies of the present invention may be generated by any suitable
25 method known in the art.

The antibodies of the present invention may comprise polyclonal antibodies. Methods of preparing polyclonal antibodies are known to the skilled artisan (Harlow, et al., *Antibodies: A Laboratory Manual*, (Cold spring Harbor Laboratory Press, 2nd ed. (1988), which is hereby incorporated herein by reference in its entirety). For
30 example, a polypeptide of the invention can be administered to various host animals including, but not limited to, rabbits, mice, rats, etc. to induce the production of sera containing polyclonal antibodies specific for the antigen. The administration of the polypeptides of the present invention may entail one or more injections of an immunizing agent and, if desired, an adjuvant. Various adjuvants may be used to
35 increase the immunological response, depending on the host species, and include but are not limited to, Freund's (complete and incomplete), mineral gels such as aluminum

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5 hydroxide, surface active substances such as lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions, keyhole limpet hemocyanins, dinitrophenol, and potentially useful human adjuvants such as BCG (bacille Calmette-Guerin) and corynebacterium parvum. Such adjuvants are also well known in the art. For the purposes of the invention, "immunizing agent" may be defined as a polypeptide of the
10 invention, including fragments, variants, and/or derivatives thereof, in addition to fusions with heterologous polypeptides and other forms of the polypeptides described herein.

Typically, the immunizing agent and/or adjuvant will be injected in the mammal by multiple subcutaneous or intraperitoneal injections, though they may also
15 be given intramuscularly, and/or through IV). The immunizing agent may include polypeptides of the present invention or a fusion protein or variants thereof. Depending upon the nature of the polypeptides (i.e., percent hydrophobicity, percent hydrophilicity, stability, net charge, isoelectric point etc.), it may be useful to conjugate the immunizing agent to a protein known to be immunogenic in the
20 mammal being immunized. Such conjugation includes either chemical conjugation by derivitizing active chemical functional groups to both the polypeptide of the present invention and the immunogenic protein such that a covalent bond is formed, or through fusion-protein based methodology, or other methods known to the skilled artisan. Examples of such immunogenic proteins include, but are not limited to
25 keyhole limpet hemocyanin, serum albumin, bovine thyroglobulin, and soybean trypsin inhibitor. Various adjuvants may be used to increase the immunological response, depending on the host species, including but not limited to Freund's (complete and incomplete), mineral gels such as aluminum hydroxide, surface active substances such as lysolecithin, pluronic polyols, polyanions, peptides, oil emulsions,
30 keyhole limpet hemocyanin, dinitrophenol, and potentially useful human adjuvants such as BCG (bacille Calmette-Guerin) and Corynebacterium parvum. Additional examples of adjuvants which may be employed includes the MPL-TDM adjuvant (monophosphoryl lipid A, synthetic trehalose dicorynomycolate). The immunization protocol may be selected by one skilled in the art without undue experimentation.

35 The antibodies of the present invention may comprise monoclonal antibodies. Monoclonal antibodies may be prepared using hybridoma methods, such as those

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5 described by Kohler and Milstein, Nature, 256:495 (1975) and U.S. Pat. No. 4,376,110, by Harlow, et al., Antibodies: A Laboratory Manual, (Cold Spring Harbor Laboratory Press, 2nd ed. (1988), by Hammerling, et al., Monoclonal Antibodies and T-Cell Hybridomas (Elsevier, N.Y., (1981)), or other methods known to the artisan. Other examples of methods which may be employed for producing monoclonal
10 antibodies includes, but are not limited to, the human B-cell hybridoma technique (Kosbor et al., 1983, Immunology Today 4:72; Cole et al., 1983, Proc. Natl. Acad. Sci. USA 80:2026-2030), and the EBV-hybridoma technique (Cole et al., 1985, Monoclonal Antibodies And Cancer Therapy, Alan R. Liss, Inc., pp. 77-96). Such antibodies may be of any immunoglobulin class including IgG, IgM, IgE, IgA, IgD
15 and any subclass thereof. The hybridoma producing the mAb of this invention may be cultivated in vitro or in vivo. Production of high titers of mAbs in vivo makes this the presently preferred method of production.

In a hybridoma method, a mouse, a humanized mouse, a mouse with a human immune system, hamster, or other appropriate host animal, is typically immunized
20 with an immunizing agent to elicit lymphocytes that produce or are capable of producing antibodies that will specifically bind to the immunizing agent. Alternatively, the lymphocytes may be immunized in vitro.

The immunizing agent will typically include polypeptides of the present invention or a fusion protein thereof. Generally, either peripheral blood lymphocytes
25 ("PBLs") are used if cells of human origin are desired, or spleen cells or lymph node cells are used if non-human mammalian sources are desired. The lymphocytes are then fused with an immortalized cell line using a suitable fusing agent, such as polyethylene glycol, to form a hybridoma cell (Goding, Monoclonal Antibodies: Principles and Practice, Academic Press, (1986), pp. 59-103). Immortalized cell lines
30 are usually transformed mammalian cells, particularly myeloma cells of rodent, bovine and human origin. Usually, rat or mouse myeloma cell lines are employed. The hybridoma cells may be cultured in a suitable culture medium that preferably contains one or more substances that inhibit the growth or survival of the unfused, immortalized cells. For example, if the parental cells lack the enzyme hypoxanthine
35 guanine phosphoribosyl transferase (HGPRT or HPRT), the culture medium for the

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5 hybridomas typically will include hypoxanthine, aminopterin, and thymidine ("HAT medium"), which substances prevent the growth of HGPRT-deficient cells.

Preferred immortalized cell lines are those that fuse efficiently, support stable high level expression of antibody by the selected antibody-producing cells, and are sensitive to a medium such as HAT medium. More preferred immortalized cell lines
 10 are murine myeloma lines, which can be obtained, for instance, from the Salk Institute Cell Distribution Center, San Diego, California and the American Type Culture Collection, Manassas, Virginia. As inferred throughout the specification, human myeloma and mouse-human heteromyeloma cell lines also have been described for the production of human monoclonal antibodies (Kozbor, J. Immunol., 133:3001
 15 (1984); Brodeur et al., Monoclonal Antibody Production Techniques and Applications, Marcel Dekker, Inc., New York, (1987) pp. 51-63).

The culture medium in which the hybridoma cells are cultured can then be assayed for the presence of monoclonal antibodies directed against the polypeptides of the present invention. Preferably, the binding specificity of monoclonal antibodies
 20 produced by the hybridoma cells is determined by immunoprecipitation or by an in vitro binding assay, such as radioimmunoassay (RIA) or enzyme-linked immunoabsorbant assay (ELISA). Such techniques are known in the art and within the skill of the artisan. The binding affinity of the monoclonal antibody can, for example, be determined by the Scatchard analysis of Munson and Pollart, Anal.
 25 Biochem., 107:220 (1980).

After the desired hybridoma cells are identified, the clones may be subcloned by limiting dilution procedures and grown by standard methods (Goding, supra). Suitable culture media for this purpose include, for example, Dulbecco's Modified Eagle's Medium and RPMI-1640. Alternatively, the hybridoma cells may be grown in
 30 vivo as ascites in a mammal.

The monoclonal antibodies secreted by the subclones may be isolated or purified from the culture medium or ascites fluid by conventional immunoglobulin purification procedures such as, for example, protein A-sepharose, hydroxyapatite chromatography, gel exclusion chromatography, gel electrophoresis, dialysis, or
 35 affinity chromatography.

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5 The skilled artisan would acknowledge that a variety of methods exist in the art for the production of monoclonal antibodies and thus, the invention is not limited to their sole production in hydridomas. For example, the monoclonal antibodies may be made by recombinant DNA methods, such as those described in US patent No. 4, 816, 567. In this context, the term “monoclonal antibody” refers to an antibody
10 derived from a single eukaryotic, phage, or prokaryotic clone. The DNA encoding the monoclonal antibodies of the invention can be readily isolated and sequenced using conventional procedures (e.g., by using oligonucleotide probes that are capable of binding specifically to genes encoding the heavy and light chains of murine antibodies, or such chains from human, humanized, or other sources). The hydridoma
15 cells of the invention serve as a preferred source of such DNA. Once isolated, the DNA may be placed into expression vectors, which are then transformed into host cells such as Simian COS cells, Chinese hamster ovary (CHO) cells, or myeloma cells that do not otherwise produce immunoglobulin protein, to obtain the synthesis of monoclonal antibodies in the recombinant host cells. The DNA also may be modified,
20 for example, by substituting the coding sequence for human heavy and light chain constant domains in place of the homologous murine sequences (US Patent No. 4, 816, 567; Morrison et al, supra) or by covalently joining to the immunoglobulin coding sequence all or part of the coding sequence for a non-immunoglobulin polypeptide. Such a non-immunoglobulin polypeptide can be substituted for the
25 constant domains of an antibody of the invention, or can be substituted for the variable domains of one antigen-combining site of an antibody of the invention to create a chimeric bivalent antibody.

 The antibodies may be monovalent antibodies. Methods for preparing monovalent antibodies are well known in the art. For example, one method involves
30 recombinant expression of immunoglobulin light chain and modified heavy chain. The heavy chain is truncated generally at any point in the Fc region so as to prevent heavy chain crosslinking. Alternatively, the relevant cysteine residues are substituted with another amino acid residue or are deleted so as to prevent crosslinking.

 In vitro methods are also suitable for preparing monovalent antibodies.
35 Digestion of antibodies to produce fragments thereof, particularly, Fab fragments, can be accomplished using routine techniques known in the art. Monoclonal antibodies

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5 can be prepared using a wide variety of techniques known in the art including the use of hybridoma, recombinant, and phage display technologies, or a combination thereof. For example, monoclonal antibodies can be produced using hybridoma techniques including those known in the art and taught, for example, in Harlow et al., *Antibodies: A Laboratory Manual*, (Cold Spring Harbor Laboratory Press, 2nd ed. 1988);
 10 Hammerling, et al., in: *Monoclonal Antibodies and T-Cell Hybridomas* 563-681 (Elsevier, N.Y., 1981) (said references incorporated by reference in their entireties). The term "monoclonal antibody" as used herein is not limited to antibodies produced through hybridoma technology. The term "monoclonal antibody" refers to an antibody that is derived from a single clone, including any eukaryotic, prokaryotic, or
 15 phage clone, and not the method by which it is produced.

Methods for producing and screening for specific antibodies using hybridoma technology are routine and well known in the art and are discussed in detail in the Examples described herein. In a non-limiting example, mice can be immunized with a polypeptide of the invention or a cell expressing such peptide. Once an immune
 20 response is detected, e.g., antibodies specific for the antigen are detected in the mouse serum, the mouse spleen is harvested and splenocytes isolated. The splenocytes are then fused by well known techniques to any suitable myeloma cells, for example cells from cell line SP20 available from the ATCC. Hybridomas are selected and cloned by limited dilution. The hybridoma clones are then assayed by methods known in the art
 25 for cells that secrete antibodies capable of binding a polypeptide of the invention. Ascites fluid, which generally contains high levels of antibodies, can be generated by immunizing mice with positive hybridoma clones.

Accordingly, the present invention provides methods of generating monoclonal antibodies as well as antibodies produced by the method comprising
 30 culturing a hybridoma cell secreting an antibody of the invention wherein, preferably, the hybridoma is generated by fusing splenocytes isolated from a mouse immunized with an antigen of the invention with myeloma cells and then screening the hybridomas resulting from the fusion for hybridoma clones that secrete an antibody able to bind a polypeptide of the invention.

35 Antibody fragments which recognize specific epitopes may be generated by known techniques. For example, Fab and F(ab')₂ fragments of the invention may be

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5 produced by proteolytic cleavage of immunoglobulin molecules, using enzymes such as papain (to produce Fab fragments) or pepsin (to produce F(ab')₂ fragments). F(ab')₂ fragments contain the variable region, the light chain constant region and the CH1 domain of the heavy chain.

For example, the antibodies of the present invention can also be generated
10 using various phage display methods known in the art. In phage display methods, functional antibody domains are displayed on the surface of phage particles which carry the polynucleotide sequences encoding them. In a particular embodiment, such phage can be utilized to display antigen binding domains expressed from a repertoire or combinatorial antibody library (e.g., human or murine). Phage expressing an
15 antigen binding domain that binds the antigen of interest can be selected or identified with antigen, e.g., using labeled antigen or antigen bound or captured to a solid surface or bead. Phage used in these methods are typically filamentous phage including fd and M13 binding domains expressed from phage with Fab, Fv or disulfide stabilized Fv antibody domains recombinantly fused to either the phage gene
20 III or gene VIII protein. Examples of phage display methods that can be used to make the antibodies of the present invention include those disclosed in Brinkman et al., J. Immunol. Methods 182:41-50 (1995); Ames et al., J. Immunol. Methods 184:177-186 (1995); Kettleborough et al., Eur. J. Immunol. 24:952-958 (1994); Persic et al., Gene 187 9-18 (1997); Burton et al., Advances in Immunology 57:191-280 (1994); PCT application No. PCT/GB91/01134; PCT publications WO 90/02809; WO 91/10737; WO 92/01047; WO 92/18619; WO 93/11236; WO 95/15982; WO 95/20401; and U.S.
25 Patent Nos. 5,698,426; 5,223,409; 5,403,484; 5,580,717; 5,427,908; 5,750,753; 5,821,047; 5,571,698; 5,427,908; 5,516,637; 5,780,225; 5,658,727; 5,733,743 and 5,969,108; each of which is incorporated herein by reference in its entirety.

30 As described in the above references, after phage selection, the antibody coding regions from the phage can be isolated and used to generate whole antibodies, including human antibodies, or any other desired antigen binding fragment, and expressed in any desired host, including mammalian cells, insect cells, plant cells, yeast, and bacteria, e.g., as described in detail below. For example, techniques to
35 recombinantly produce Fab, Fab' and F(ab')₂ fragments can also be employed using methods known in the art such as those disclosed in PCT publication WO 92/22324;

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5 Mullinax et al., BioTechniques 12(6):864-869 (1992); and Sawai et al., AJRI 34:26-34 (1995); and Better et al., Science 240:1041-1043 (1988) (said references incorporated by reference in their entireties). Examples of techniques which can be used to produce single-chain Fvs and antibodies include those described in U.S. Patents 4,946,778 and 5,258,498; Huston et al., Methods in Enzymology 203:46-88
10 (1991); Shu et al., PNAS 90:7995-7999 (1993); and Skerra et al., Science 240:1038-1040 (1988).

For some uses, including in vivo use of antibodies in humans and in vitro detection assays, it may be preferable to use chimeric, humanized, or human antibodies. A chimeric antibody is a molecule in which different portions of the
15 antibody are derived from different animal species, such as antibodies having a variable region derived from a murine monoclonal antibody and a human immunoglobulin constant region. Methods for producing chimeric antibodies are known in the art. See e.g., Morrison, Science 229:1202 (1985); Oi et al., BioTechniques 4:214 (1986); Gillies et al., (1989) J. Immunol. Methods 125:191-202;
20 U.S. Patent Nos. 5,807,715; 4,816,567; and 4,816,397, which are incorporated herein by reference in their entirety. Humanized antibodies are antibody molecules from non-human species antibody that binds the desired antigen having one or more complementarity determining regions (CDRs) from the non-human species and a framework regions from a human immunoglobulin molecule. Often, framework
25 residues in the human framework regions will be substituted with the corresponding residue from the CDR donor antibody to alter, preferably improve, antigen binding. These framework substitutions are identified by methods well known in the art, e.g., by modeling of the interactions of the CDR and framework residues to identify framework residues important for antigen binding and sequence comparison to
30 identify unusual framework residues at particular positions. (See, e.g., Queen et al., U.S. Patent No. 5,585,089; Riechmann et al., Nature 332:323 (1988), which are incorporated herein by reference in their entireties.) Antibodies can be humanized using a variety of techniques known in the art including, for example, CDR-grafting (EP 239,400; PCT publication WO 91/09967; U.S. Patent Nos. 5,225,539; 5,530,101;
35 and 5,585,089), veneering or resurfacing (EP 592,106; EP 519,596; Padlan, Molecular Immunology 28(4/5):489-498 (1991); Studnicka et al., Protein Engineering 7(6):805-

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5 814 (1994); Roguska. et al., PNAS 91:969-973 (1994)), and chain shuffling (U.S. Patent No. 5,565,332). Generally, a humanized antibody has one or more amino acid residues introduced into it from a source that is non-human. These non-human amino acid residues are often referred to as "import" residues, which are typically taken from an "import" variable domain. Humanization can be essentially performed following
10 the methods of Winter and co-workers (Jones et al., Nature, 321:522-525 (1986); Reichmann et al., Nature, 332:323-327 (1988); Verhoeyen et al., Science, 239:1534-1536 (1988), by substituting rodent CDRs or CDR sequences for the corresponding sequences of a human antibody. Accordingly, such "humanized" antibodies are chimeric antibodies (US Patent No. 4, 816, 567), wherein substantially less than an
15 intact human variable domain has been substituted by the corresponding sequence from a non-human species. In practice, humanized antibodies are typically human antibodies in which some CDR residues and possible some FR residues are substituted from analogous sites in rodent antibodies.

In general, the humanized antibody will comprise substantially all of at least
20 one, and typically two, variable domains, in which all or substantially all of the CDR regions correspond to those of a non-human immunoglobulin and all or substantially all of the FR regions are those of a human immunoglobulin consensus sequence. The humanized antibody optimally also will comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin
25 (Jones et al., Nature, 321:522-525 (1986); Riechmann et al., Nature 332:323-329 (1988)l and Presta, Curr. Op. Struct. Biol., 2:593-596 (1992).

Completely human antibodies are particularly desirable for therapeutic treatment of human patients. Human antibodies can be made by a variety of methods known in the art including phage display methods described above using antibody
30 libraries derived from human immunoglobulin sequences. See also, U.S. Patent Nos. 4,444,887 and 4,716,111; and PCT publications WO 98/46645, WO 98/50433, WO 98/24893, WO 98/16654, WO 96/34096, WO 96/33735, and WO 91/10741; each of which is incorporated herein by reference in its entirety. The techniques of cole et al., and Boerder et al., are also available for the preparation of human monoclonal
35 antibodies (cole et al., Monoclonal Antibodies and Cancer Therapy, Alan R. Riss, (1985); and Boerner et al., J. Immunol., 147(1):86-95, (1991)).

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5 Human antibodies can also be produced using transgenic mice which are incapable of expressing functional endogenous immunoglobulins, but which can express human immunoglobulin genes. For example, the human heavy and light chain immunoglobulin gene complexes may be introduced randomly or by homologous recombination into mouse embryonic stem cells. Alternatively, the human variable
10 region, constant region, and diversity region may be introduced into mouse embryonic stem cells in addition to the human heavy and light chain genes. The mouse heavy and light chain immunoglobulin genes may be rendered non-functional separately or simultaneously with the introduction of human immunoglobulin loci by homologous recombination. In particular, homozygous deletion of the JH region prevents
15 endogenous antibody production. The modified embryonic stem cells are expanded and microinjected into blastocysts to produce chimeric mice. The chimeric mice are then bred to produce homozygous offspring which express human antibodies. The transgenic mice are immunized in the normal fashion with a selected antigen, e.g., all or a portion of a polypeptide of the invention. Monoclonal antibodies directed against
20 the antigen can be obtained from the immunized, transgenic mice using conventional hybridoma technology. The human immunoglobulin transgenes harbored by the transgenic mice rearrange during B cell differentiation, and subsequently undergo class switching and somatic mutation. Thus, using such a technique, it is possible to produce therapeutically useful IgG, IgA, IgM and IgE antibodies. For an overview of
25 this technology for producing human antibodies, see Lonberg and Huszar, *Int. Rev. Immunol.* 13:65-93 (1995). For a detailed discussion of this technology for producing human antibodies and human monoclonal antibodies and protocols for producing such antibodies, see, e.g., PCT publications WO 98/24893; WO 92/01047; WO 96/34096; WO 96/33735; European Patent No. 0 598 877; U.S. Patent Nos. 5,413,923;
30 5,625,126; 5,633,425; 5,569,825; 5,661,016; 5,545,806; 5,814,318; 5,885,793; 5,916,771; and 5,939,598, which are incorporated by reference herein in their entirety. In addition, companies such as Abgenix, Inc. (Freemont, CA), Genpharm (San Jose, CA), and Medarex, Inc. (Princeton, NJ) can be engaged to provide human antibodies directed against a selected antigen using technology similar to that described above.

35 Similarly, human antibodies can be made by introducing human immunoglobulin loci into transgenic animals, e.g., mice in which the endogenous

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5 immunoglobulin genes have been partially or completely inactivated. Upon challenge, human antibody production is observed, which closely resembles that seen in humans in all respects, including gene rearrangement, assembly, and creation of an antibody repertoire. This approach is described, for example, in US patent Nos. 5,545,807; 5,545,806; 5,569,825; 5,625,126; 5,633,425; 5,661,106, and in the following scientific
10 publications: Marks et al., *Biotechnol.*, 10:779-783 (1992); Lonberg et al., *Nature* 368:856-859 (1994); Fishwild et al., *Nature Biotechnol.*, 14:845-51 (1996); Neuberger, *Nature Biotechnol.*, 14:826 (1996); Lonberg and Huszer, *Intern. Rev. Immunol.*, 13:65-93 (1995).

Completely human antibodies which recognize a selected epitope can be
15 generated using a technique referred to as "guided selection." In this approach a selected non-human monoclonal antibody, e.g., a mouse antibody, is used to guide the selection of a completely human antibody recognizing the same epitope. (Jespers et al., *Bio/technology* 12:899-903 (1988)).

Further, antibodies to the polypeptides of the invention can, in turn, be utilized
20 to generate anti-idiotypic antibodies that "mimic" polypeptides of the invention using techniques well known to those skilled in the art. (See, e.g., Greenspan & Bona, *FASEB J.* 7(5):437-444; (1989) and Nissinoff, *J. Immunol.* 147(8):2429-2438 (1991)). For example, antibodies which bind to and competitively inhibit polypeptide multimerization and/or binding of a polypeptide of the invention to a ligand can be
25 used to generate anti-idiotypes that "mimic" the polypeptide multimerization and/or binding domain and, as a consequence, bind to and neutralize polypeptide and/or its ligand. Such neutralizing anti-idiotypes or Fab fragments of such anti-idiotypes can be used in therapeutic regimens to neutralize polypeptide ligand. For example, such anti-idiotypic antibodies can be used to bind a polypeptide of the invention and/or to bind
30 its ligands/receptors, and thereby block its biological activity.

The antibodies of the present invention may be bispecific antibodies. Bispecific antibodies are monoclonal, Preferably human or humanized, antibodies that have binding specificities for at least two different antigens. In the present invention, one of the binding specificities may be directed towards a polypeptide of the present
35 invention, the other may be for any other antigen, and preferably for a cell-surface protein, receptor, receptor subunit, tissue-specific antigen, virally derived protein,

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5 virally encoded envelope protein, bacterially derived protein, or bacterial surface protein, etc.

Methods for making bispecific antibodies are known in the art. Traditionally, the recombinant production of bispecific antibodies is based on the co-expression of two immunoglobulin heavy-chain/light-chain pairs, where the two heavy chains have
10 different specificities (Milstein and Cuello, *Nature*, 305:537-539 (1983). Because of the random assortment of immunoglobulin heavy and light chains, these hybridomas (quadromas) produce a potential mixture of ten different antibody molecules, of which only one has the correct bispecific structure. The purification of the correct molecule is usually accomplished by affinity chromatography steps. Similar
15 procedures are disclosed in WO 93/08829, published 13 May 1993, and in Traunecker et al., *EMBO J.*, 10:3655-3659 (1991).

Antibody variable domains with the desired binding specificities (antibody-antigen combining sites) can be fused to immunoglobulin constant domain sequences. The fusion preferably is with an immunoglobulin heavy-chain constant domain, comprising at least part of the hinge, CH2, and CH3 regions. It is preferred to have
20 the first heavy-chain constant region (CH1) containing the site necessary for light-chain binding present in at least one of the fusions. DNAs encoding the immunoglobulin heavy-chain fusions and, if desired, the immunoglobulin light chain, are inserted into separate expression vectors, and are co-transformed into a suitable
25 host organism. For further details of generating bispecific antibodies see, for example Suresh et al., *Meth. In Enzym.*, 121:210 (1986).

Heteroconjugate antibodies are also contemplated by the present invention. Heteroconjugate antibodies are composed of two covalently joined antibodies. Such antibodies have, for example, been proposed to target immune system cells to
30 unwanted cells (US Patent No. 4, 676, 980), and for the treatment of HIV infection (WO 91/00360; WO 92/20373; and EP03089). It is contemplated that the antibodies may be prepared in vitro using known methods in synthetic protein chemistry, including those involving crosslinking agents. For example, immunotoxins may be constructed using a disulfide exchange reaction or by forming a thioester bond.
35 Examples of suitable reagents for this purpose include iminothiolate and methyl-4-mercaptobutyrimidate and those disclosed, for example, in US Patent No. 4,676,980.

5

Polynucleotides Encoding Antibodies

The invention further provides polynucleotides comprising a nucleotide sequence encoding an antibody of the invention and fragments thereof. The invention also encompasses polynucleotides that hybridize under stringent or lower stringency
10 hybridization conditions, e.g., as defined supra, to polynucleotides that encode an antibody, preferably, that specifically binds to a polypeptide of the invention, preferably, an antibody that binds to a polypeptide having the amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24.

The polynucleotides may be obtained, and the nucleotide sequence of the
15 polynucleotides determined, by any method known in the art. For example, if the nucleotide sequence of the antibody is known, a polynucleotide encoding the antibody may be assembled from chemically synthesized oligonucleotides (e.g., as described in Kutmeier et al., BioTechniques 17:242 (1994)), which, briefly, involves the synthesis of overlapping oligonucleotides containing portions of the sequence encoding the
20 antibody, annealing and ligating of those oligonucleotides, and then amplification of the ligated oligonucleotides by PCR.

Alternatively, a polynucleotide encoding an antibody may be generated from nucleic acid from a suitable source. If a clone containing a nucleic acid encoding a particular antibody is not available, but the sequence of the antibody molecule is
25 known, a nucleic acid encoding the immunoglobulin may be chemically synthesized or obtained from a suitable source (e.g., an antibody cDNA library, or a cDNA library generated from, or nucleic acid, preferably poly A+ RNA, isolated from, any tissue or cells expressing the antibody, such as hybridoma cells selected to express an antibody of the invention) by PCR amplification using synthetic primers hybridizable to the 3'
30 and 5' ends of the sequence or by cloning using an oligonucleotide probe specific for the particular gene sequence to identify, e.g., a cDNA clone from a cDNA library that encodes the antibody. Amplified nucleic acids generated by PCR may then be cloned into replicable cloning vectors using any method well known in the art.

Once the nucleotide sequence and corresponding amino acid sequence of the
35 antibody is determined, the nucleotide sequence of the antibody may be manipulated using methods well known in the art for the manipulation of nucleotide sequences,

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5 e.g., recombinant DNA techniques, site directed mutagenesis, PCR, etc. (see, for example, the techniques described in Sambrook et al., 1990, Molecular Cloning, A Laboratory Manual, 2d Ed., Cold Spring Harbor Laboratory, Cold Spring Harbor, NY and Ausubel et al., eds., 1998, Current Protocols in Molecular Biology, John Wiley & Sons, NY, which are both incorporated by reference herein in their entirety), to
10 generate antibodies having a different amino acid sequence, for example to create amino acid substitutions, deletions, and/or insertions.

In a specific embodiment, the amino acid sequence of the heavy and/or light chain variable domains may be inspected to identify the sequences of the complementarity determining regions (CDRs) by methods that are well known in the art, e.g., by comparison to known amino acid sequences of other heavy and light chain
15 variable regions to determine the regions of sequence hypervariability. Using routine recombinant DNA techniques, one or more of the CDRs may be inserted within framework regions, e.g., into human framework regions to humanize a non-human antibody, as described supra. The framework regions may be naturally occurring or
20 consensus framework regions, and preferably human framework regions (see, e.g., Chothia et al., J. Mol. Biol. 278: 457-479 (1998) for a listing of human framework regions). Preferably, the polynucleotide generated by the combination of the framework regions and CDRs encodes an antibody that specifically binds a polypeptide of the invention. Preferably, as discussed supra, one or more amino acid
25 substitutions may be made within the framework regions, and, preferably, the amino acid substitutions improve binding of the antibody to its antigen. Additionally, such methods may be used to make amino acid substitutions or deletions of one or more variable region cysteine residues participating in an intrachain disulfide bond to generate antibody molecules lacking one or more intrachain disulfide bonds. Other
30 alterations to the polynucleotide are encompassed by the present invention and within the skill of the art.

In addition, techniques developed for the production of "chimeric antibodies" (Morrison et al., Proc. Natl. Acad. Sci. 81:851-855 (1984); Neuberger et al., Nature 312:604-608 (1984); Takeda et al., Nature 314:452-454 (1985)) by splicing genes
35 from a mouse antibody molecule of appropriate antigen specificity together with genes from a human antibody molecule of appropriate biological activity can be used.

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5 As described supra, a chimeric antibody is a molecule in which different portions are derived from different animal species, such as those having a variable region derived from a murine mAb and a human immunoglobulin constant region, e.g., humanized antibodies.

Alternatively, techniques described for the production of single chain
 10 antibodies (U.S. Patent No. 4,946,778; Bird, Science 242:423- 42 (1988); Huston et al., Proc. Natl. Acad. Sci. USA 85:5879-5883 (1988); and Ward et al., Nature 334:544-54 (1989)) can be adapted to produce single chain antibodies. Single chain antibodies are formed by linking the heavy and light chain fragments of the Fv region via an amino acid bridge, resulting in a single chain polypeptide. Techniques for the
 15 assembly of functional Fv fragments in E. coli may also be used (Skerra et al., Science 242:1038- 1041 (1988)).

Methods of Producing Antibodies

The antibodies of the invention can be produced by any method known in the
 20 art for the synthesis of antibodies, in particular, by chemical synthesis or preferably, by recombinant expression techniques.

Recombinant expression of an antibody of the invention, or fragment, derivative or analog thereof, (e.g., a heavy or light chain of an antibody of the invention or a single chain antibody of the invention), requires construction of an
 25 expression vector containing a polynucleotide that encodes the antibody. Once a polynucleotide encoding an antibody molecule or a heavy or light chain of an antibody, or portion thereof (preferably containing the heavy or light chain variable domain), of the invention has been obtained, the vector for the production of the antibody molecule may be produced by recombinant DNA technology using
 30 techniques well known in the art. Thus, methods for preparing a protein by expressing a polynucleotide containing an antibody encoding nucleotide sequence are described herein. Methods which are well known to those skilled in the art can be used to construct expression vectors containing antibody coding sequences and appropriate transcriptional and translational control signals. These methods include, for example,
 35 in vitro recombinant DNA techniques, synthetic techniques, and in vivo genetic recombination. The invention, thus, provides replicable vectors comprising a

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5 nucleotide sequence encoding an antibody molecule of the invention, or a heavy or light chain thereof, or a heavy or light chain variable domain, operably linked to a promoter. Such vectors may include the nucleotide sequence encoding the constant region of the antibody molecule (see, e.g., PCT Publication WO 86/05807; PCT Publication WO 89/01036; and U.S. Patent No. 5,122,464) and the variable domain of
10 the antibody may be cloned into such a vector for expression of the entire heavy or light chain.

The expression vector is transferred to a host cell by conventional techniques and the transfected cells are then cultured by conventional techniques to produce an antibody of the invention. Thus, the invention includes host cells containing a
15 polynucleotide encoding an antibody of the invention, or a heavy or light chain thereof, or a single chain antibody of the invention, operably linked to a heterologous promoter. In preferred embodiments for the expression of double-chained antibodies, vectors encoding both the heavy and light chains may be co-expressed in the host cell for expression of the entire immunoglobulin molecule, as detailed below.

20 A variety of host-expression vector systems may be utilized to express the antibody molecules of the invention. Such host-expression systems represent vehicles by which the coding sequences of interest may be produced and subsequently purified, but also represent cells which may, when transformed or transfected with the appropriate nucleotide coding sequences, express an antibody molecule of the
25 invention in situ. These include but are not limited to microorganisms such as bacteria (e.g., *E. coli*, *B. subtilis*) transformed with recombinant bacteriophage DNA, plasmid DNA or cosmid DNA expression vectors containing antibody coding sequences; yeast (e.g., *Saccharomyces*, *Pichia*) transformed with recombinant yeast expression vectors containing antibody coding sequences; insect cell systems infected with recombinant
30 virus expression vectors (e.g., baculovirus) containing antibody coding sequences; plant cell systems infected with recombinant virus expression vectors (e.g., cauliflower mosaic virus, CaMV; tobacco mosaic virus, TMV) or transformed with recombinant plasmid expression vectors (e.g., Ti plasmid) containing antibody coding sequences; or mammalian cell systems (e.g., COS, CHO, BHK, 293, 3T3 cells)
35 harboring recombinant expression constructs containing promoters derived from the genome of mammalian cells (e.g., metallothionein promoter) or from mammalian

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5 viruses (e.g., the adenovirus late promoter; the vaccinia virus 7.5K promoter). Preferably, bacterial cells such as *Escherichia coli*, and more preferably, eukaryotic cells, especially for the expression of whole recombinant antibody molecule, are used for the expression of a recombinant antibody molecule. For example, mammalian cells such as Chinese hamster ovary cells (CHO), in conjunction with a vector such as
10 the major intermediate early gene promoter element from human cytomegalovirus is an effective expression system for antibodies (Foecking et al., *Gene* 45:101 (1986); Cockett et al., *Bio/Technology* 8:2 (1990)).

In bacterial systems, a number of expression vectors may be advantageously selected depending upon the use intended for the antibody molecule being expressed.
15 For example, when a large quantity of such a protein is to be produced, for the generation of pharmaceutical compositions of an antibody molecule, vectors which direct the expression of high levels of fusion protein products that are readily purified may be desirable. Such vectors include, but are not limited, to the *E. coli* expression vector pUR278 (Ruther et al., *EMBO J.* 2:1791 (1983)), in which the antibody coding
20 sequence may be ligated individually into the vector in frame with the lac Z coding region so that a fusion protein is produced; pIN vectors (Inouye & Inouye, *Nucleic Acids Res.* 13:3101-3109 (1985); Van Heeke & Schuster, *J. Biol. Chem.* 264:5503-5509 (1989)); and the like. pGEX vectors may also be used to express foreign polypeptides as fusion proteins with glutathione S-transferase (GST). In general, such
25 fusion proteins are soluble and can easily be purified from lysed cells by adsorption and binding to matrix glutathione-agarose beads followed by elution in the presence of free glutathione. The pGEX vectors are designed to include thrombin or factor Xa protease cleavage sites so that the cloned target gene product can be released from the GST moiety.

30 In an insect system, *Autographa californica* nuclear polyhedrosis virus (AcNPV) is used as a vector to express foreign genes. The virus grows in *Spodoptera frugiperda* cells. The antibody coding sequence may be cloned individually into non-essential regions (for example the polyhedrin gene) of the virus and placed under control of an AcNPV promoter (for example the polyhedrin promoter).

35 In mammalian host cells, a number of viral-based expression systems may be utilized. In cases where an adenovirus is used as an expression vector, the antibody

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5 coding sequence of interest may be ligated to an adenovirus transcription/translation control complex, e.g., the late promoter and tripartite leader sequence. This chimeric gene may then be inserted in the adenovirus genome by in vitro or in vivo recombination. Insertion in a non- essential region of the viral genome (e.g., region E1 or E3) will result in a recombinant virus that is viable and capable of expressing
10 the antibody molecule in infected hosts. (e.g., see Logan & Shenk, Proc. Natl. Acad. Sci. USA 81:355-359 (1984)). Specific initiation signals may also be required for efficient translation of inserted antibody coding sequences. These signals include the ATG initiation codon and adjacent sequences. Furthermore, the initiation codon must be in phase with the reading frame of the desired coding sequence to ensure
15 translation of the entire insert. These exogenous translational control signals and initiation codons can be of a variety of origins, both natural and synthetic. The efficiency of expression may be enhanced by the inclusion of appropriate transcription enhancer elements, transcription terminators, etc. (see Bittner et al., Methods in Enzymol. 153:51-544 (1987)).

20 In addition, a host cell strain may be chosen which modulates the expression of the inserted sequences, or modifies and processes the gene product in the specific fashion desired. Such modifications (e.g., glycosylation) and processing (e.g., cleavage) of protein products may be important for the function of the protein. Different host cells have characteristic and specific mechanisms for the post-
25 translational processing and modification of proteins and gene products. Appropriate cell lines or host systems can be chosen to ensure the correct modification and processing of the foreign protein expressed. To this end, eukaryotic host cells which possess the cellular machinery for proper processing of the primary transcript, glycosylation, and phosphorylation of the gene product may be used. Such
30 mammalian host cells include but are not limited to CHO, VERY, BHK, Hela, COS, MDCK, 293, 3T3, WI38, and in particular, breast cancer cell lines such as, for example, BT483, Hs578T, HTB2, BT20 and T47D, and normal mammary gland cell line such as, for example, CRL7030 and Hs578Bst.

For long-term, high-yield production of recombinant proteins, stable
35 expression is preferred. For example, cell lines which stably express the antibody molecule may be engineered. Rather than using expression vectors which contain

5 viral origins of replication, host cells can be transformed with DNA controlled by appropriate expression control elements (e.g., promoter, enhancer, sequences, transcription terminators, polyadenylation sites, etc.), and a selectable marker. Following the introduction of the foreign DNA, engineered cells may be allowed to grow for 1-2 days in an enriched media, and then are switched to a selective media.

10 The selectable marker in the recombinant plasmid confers resistance to the selection and allows cells to stably integrate the plasmid into their chromosomes and grow to form foci which in turn can be cloned and expanded into cell lines. This method may advantageously be used to engineer cell lines which express the antibody molecule. Such engineered cell lines may be particularly useful in screening and evaluation of

15 compounds that interact directly or indirectly with the antibody molecule.

A number of selection systems may be used, including but not limited to the herpes simplex virus thymidine kinase (Wigler et al., Cell 11:223 (1977)), hypoxanthine-guanine phosphoribosyltransferase (Szybalska & Szybalski, Proc. Natl. Acad. Sci. USA 48:202 (1992)), and adenine phosphoribosyltransferase (Lowy et al.,

20 Cell 22:817 (1980)) genes can be employed in tk-, hgp^rt- or ap^rt- cells, respectively. Also, antimetabolite resistance can be used as the basis of selection for the following genes: dhfr, which confers resistance to methotrexate (Wigler et al., Natl. Acad. Sci. USA 77:357 (1980); O'Hare et al., Proc. Natl. Acad. Sci. USA 78:1527 (1981)); gpt, which confers resistance to mycophenolic acid (Mulligan & Berg, Proc. Natl. Acad.

25 Sci. USA 78:2072 (1981)); neo, which confers resistance to the aminoglycoside G-418 Clinical Pharmacy 12:488-505; Wu and Wu, Biotherapy 3:87-95 (1991); Tolstoshev, Ann. Rev. Pharmacol. Toxicol. 32:573-596 (1993); Mulligan, Science 260:926-932 (1993); and Morgan and Anderson, Ann. Rev. Biochem. 62:191-217 (1993); May, 1993, TIB TECH 11(5):155-215); and hyg^r, which confers resistance

30 to hygromycin (Santerre et al., Gene 30:147 (1984)). Methods commonly known in the art of recombinant DNA technology may be routinely applied to select the desired recombinant clone, and such methods are described, for example, in Ausubel et al. (eds.), Current Protocols in Molecular Biology, John Wiley & Sons, NY (1993); Kriegler, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY

35 (1990); and in Chapters 12 and 13, Dracopoli et al. (eds), Current Protocols in Human Genetics, John Wiley & Sons, NY (1994); Colberre-Garapin et al., J. Mol. Biol. 150:1

5 (1981), which are incorporated by reference herein in their entireties.

The expression levels of an antibody molecule can be increased by vector amplification (for a review, see Bebbington and Hentschel, The use of vectors based on gene amplification for the expression of cloned genes in mammalian cells in DNA cloning, Vol.3. (Academic Press, New York, 1987)). When a marker in the vector
10 system expressing antibody is amplifiable, increase in the level of inhibitor present in culture of host cell will increase the number of copies of the marker gene. Since the amplified region is associated with the antibody gene, production of the antibody will also increase (Crouse et al., Mol. Cell. Biol. 3:257 (1983)).

The host cell may be co-transfected with two expression vectors of the
15 invention, the first vector encoding a heavy chain derived polypeptide and the second vector encoding a light chain derived polypeptide. The two vectors may contain identical selectable markers which enable equal expression of heavy and light chain polypeptides. Alternatively, a single vector may be used which encodes, and is capable of expressing, both heavy and light chain polypeptides. In such situations, the
20 light chain should be placed before the heavy chain to avoid an excess of toxic free heavy chain (Proudfoot, Nature 322:52 (1986); Kohler, Proc. Natl. Acad. Sci. USA 77:2197 (1980)). The coding sequences for the heavy and light chains may comprise cDNA or genomic DNA.

Once an antibody molecule of the invention has been produced by an animal,
25 chemically synthesized, or recombinantly expressed, it may be purified by any method known in the art for purification of an immunoglobulin molecule, for example, by chromatography (e.g., ion exchange, affinity, particularly by affinity for the specific antigen after Protein A, and sizing column chromatography),
centrifugation, differential solubility, or by any other standard technique for the
30 purification of proteins. In addition, the antibodies of the present invention or fragments thereof can be fused to heterologous polypeptide sequences described herein or otherwise known in the art, to facilitate purification.

The present invention encompasses antibodies recombinantly fused or chemically conjugated (including both covalently and non-covalently conjugations) to
35 a polypeptide (or portion thereof, preferably at least 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100 amino acids of the polypeptide) of the present invention to generate fusion

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5 proteins. The fusion does not necessarily need to be direct, but may occur through linker sequences. The antibodies may be specific for antigens other than polypeptides (or portion thereof, preferably at least 10, 20, 30, 40, 50, 60, 70, 80, 90 or 100 amino acids of the polypeptide) of the present invention. For example, antibodies may be used to target the polypeptides of the present invention to particular cell types, either
10 in vitro or in vivo, by fusing or conjugating the polypeptides of the present invention to antibodies specific for particular cell surface receptors. Antibodies fused or conjugated to the polypeptides of the present invention may also be used in in vitro immunoassays and purification methods using methods known in the art. See e.g., Harbor et al., supra, and PCT publication WO 93/21232; EP 439,095; Naramura et al.,
15 Immunol. Lett. 39:91-99 (1994); U.S. Patent 5,474,981; Gillies et al., PNAS 89:1428-1432 (1992); Fell et al., J. Immunol. 146:2446-2452(1991), which are incorporated by reference in their entirety.

The present invention further includes compositions comprising the polypeptides of the present invention fused or conjugated to antibody domains other
20 than the variable regions. For example, the polypeptides of the present invention may be fused or conjugated to an antibody Fc region, or portion thereof. The antibody portion fused to a polypeptide of the present invention may comprise the constant region, hinge region, CH1 domain, CH2 domain, and CH3 domain or any combination of whole domains or portions thereof. The polypeptides may also be
25 fused or conjugated to the above antibody portions to form multimers. For example, Fc portions fused to the polypeptides of the present invention can form dimers through disulfide bonding between the Fc portions. Higher multimeric forms can be made by fusing the polypeptides to portions of IgA and IgM. Methods for fusing or conjugating the polypeptides of the present invention to antibody portions are known
30 in the art. See, e.g., U.S. Patent Nos. 5,336,603; 5,622,929; 5,359,046; 5,349,053; 5,447,851; 5,112,946; EP 307,434; EP 367,166; PCT publications WO 96/04388; WO 91/06570; Ashkenazi et al., Proc. Natl. Acad. Sci. USA 88:10535-10539 (1991); Zheng et al., J. Immunol. 154:5590-5600 (1995); and Vil et al., Proc. Natl. Acad. Sci. USA 89:11337- 11341(1992) (said references incorporated by reference in their
35 entirety).

As discussed, supra, the polypeptides corresponding to a polypeptide,

5 polypeptide fragment, or a variant of SEQ ID NO:2, or SEQ ID NO:24, may be fused or conjugated to the above antibody portions to increase the in vivo half life of the polypeptides or for use in immunoassays using methods known in the art. Further, the polypeptides corresponding to SEQ ID NO:2, or SEQ ID NO:24, may be fused or conjugated to the above antibody portions to facilitate purification. One reported
10 example describes chimeric proteins consisting of the first two domains of the human CD4-polypeptide and various domains of the constant regions of the heavy or light chains of mammalian immunoglobulins. (EP 394,827; Traunecker et al., Nature 331:84-86 (1988). The polypeptides of the present invention fused or conjugated to an antibody having disulfide- linked dimeric structures (due to the IgG) may also be
15 more efficient in binding and neutralizing other molecules, than the monomeric secreted protein or protein fragment alone. (Fountoulakis et al., J. Biochem. 270:3958-3964 (1995)). In many cases, the Fc part in a fusion protein is beneficial in therapy and diagnosis, and thus can result in, for example, improved pharmacokinetic properties. (EP A 232,262). Alternatively, deleting the Fc part after the fusion protein
20 has been expressed, detected, and purified, would be desired. For example, the Fc portion may hinder therapy and diagnosis if the fusion protein is used as an antigen for immunizations. In drug discovery, for example, human proteins, such as hIL-5, have been fused with Fc portions for the purpose of high-throughput screening assays to identify antagonists of hIL-5. (See, Bennett et al., J. Molecular Recognition 8:52-58
25 (1995); Johanson et al., J. Biol. Chem... 270:9459-9471 (1995).

Moreover, the antibodies or fragments thereof of the present invention can be fused to marker sequences, such as a peptide to facilitate purification. In preferred embodiments, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (QIAGEN, Inc., 9259 Eton Avenue, Chatsworth, CA,
30 91311), among others, many of which are commercially available. As described in Gentz et al., Proc. Natl. Acad. Sci. USA 86:821-824 (1989), for instance, hexa-histidine provides for convenient purification of the fusion protein. Other peptide tags useful for purification include, but are not limited to, the "HA" tag, which corresponds to an epitope derived from the influenza hemagglutinin protein (Wilson
35 et al., Cell 37:767 (1984)) and the "flag" tag.

The present invention further encompasses antibodies or fragments thereof

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5 conjugated to a diagnostic or therapeutic agent. The antibodies can be used
diagnostically to, for example, monitor the development or progression of a tumor as
part of a clinical testing procedure to, e.g., determine the efficacy of a given treatment
regimen. Detection can be facilitated by coupling the antibody to a detectable
10 substance. Examples of detectable substances include various enzymes, prosthetic
groups, fluorescent materials, luminescent materials, bioluminescent materials,
radioactive materials, positron emitting metals using various positron emission
tomographies, and nonradioactive paramagnetic metal ions. The detectable substance
may be coupled or conjugated either directly to the antibody (or fragment thereof) or
indirectly, through an intermediate (such as, for example, a linker known in the art)
15 using techniques known in the art. See, for example, U.S. Patent No. 4,741,900 for
metal ions which can be conjugated to antibodies for use as diagnostics according to
the present invention. Examples of suitable enzymes include horseradish peroxidase,
alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; examples of suitable
prosthetic group complexes include streptavidin/biotin and avidin/biotin; examples of
20 suitable fluorescent materials include umbelliferone, fluorescein, fluorescein
isothiocyanate, rhodamine, dichlorotriazinylamine fluorescein, dansyl chloride or
phycoerythrin; an example of a luminescent material includes luminol; examples of
bioluminescent materials include luciferase, luciferin, and aequorin; and examples of
suitable radioactive material include ¹²⁵I, ¹³¹I, ¹¹¹In or ⁹⁹Tc.

25 Further, an antibody or fragment thereof may be conjugated to a therapeutic
moiety such as a cytotoxin, e.g., a cytostatic or cytotoxic agent, a therapeutic agent or
a radioactive metal ion, e.g., alpha-emitters such as, for example, ²¹³Bi. A cytotoxin
or cytotoxic agent includes any agent that is detrimental to cells. Examples include
paclitaxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin,
30 etoposide, teniposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin,
dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-
dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and
puromycin and analogs or homologues thereof. Therapeutic agents include, but are
not limited to, antimetabolites (e.g., methotrexate, 6-mercaptopurine, 6-thioguanine,
35 cytarabine, 5-fluorouracil decarbazine), alkylating agents (e.g., mechlorethamine,
thioepa chlorambucil, melphalan, carmustine (BSNU) and lomustine (CCNU),

5 cyclophosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin), anthracyclines (e.g., daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (e.g., dactinomycin (formerly actinomycin), bleomycin, mithramycin, and anthramycin (AMC)), and anti-mitotic agents (e.g., vincristine and vinblastine).

10 The conjugates of the invention can be used for modifying a given biological response, the therapeutic agent or drug moiety is not to be construed as limited to classical chemical therapeutic agents. For example, the drug moiety may be a protein or polypeptide possessing a desired biological activity. Such proteins may include, for example, a toxin such as abrin, ricin A, pseudomonas exotoxin, or diphtheria toxin; a
 15 protein such as tumor necrosis factor, α -interferon, β -interferon, nerve growth factor, platelet derived growth factor, tissue plasminogen activator, an apoptotic agent, e.g., TNF-alpha, TNF-beta, AIM I (See, International Publication No. WO 97/33899), AIM II (See, International Publication No. WO 97/34911), Fas Ligand (Takahashi et al., Int. Immunol., 6:1567-1574 (1994)), VEGI (See, International Publication No.
 20 WO 99/23105), a thrombotic agent or an anti- angiogenic agent, e.g., angiostatin or endostatin; or, biological response modifiers such as, for example, lymphokines, interleukin-1 ("IL-1"), interleukin-2 ("IL-2"), interleukin-6 ("IL-6"), granulocyte macrophage colony stimulating factor ("GM-CSF"), granulocyte colony stimulating factor ("G-CSF"), or other growth factors.

25 Antibodies may also be attached to solid supports, which are particularly useful for immunoassays or purification of the target antigen. Such solid supports include, but are not limited to, glass, cellulose, polyacrylamide, nylon, polystyrene, polyvinyl chloride or polypropylene.

Techniques for conjugating such therapeutic moiety to antibodies are well
 30 known, see, e.g., Arnon et al., "Monoclonal Antibodies For Immunotargeting Of Drugs In Cancer Therapy", in Monoclonal Antibodies And Cancer Therapy, Reisfeld et al. (eds.), pp. 243-56 (Alan R. Liss, Inc. 1985); Hellstrom et al., "Antibodies For Drug Delivery", in Controlled Drug Delivery (2nd Ed.), Robinson et al. (eds.), pp. 623-53 (Marcel Dekker, Inc. 1987); Thorpe, "Antibody Carriers Of Cytotoxic Agents
 35 In Cancer Therapy: A Review", in Monoclonal Antibodies '84: Biological And Clinical Applications, Pinchera et al. (eds.), pp. 475-506 (1985); "Analysis, Results,

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5 And Future Prospective Of The Therapeutic Use Of Radiolabeled Antibody In Cancer Therapy", in Monoclonal Antibodies For Cancer Detection And Therapy, Baldwin et al. (eds.), pp. 303-16 (Academic Press 1985), and Thorpe et al., "The Preparation And Cytotoxic Properties Of Antibody-Toxin Conjugates", Immunol. Rev. 62:119-58 (1982).

10 Alternatively, an antibody can be conjugated to a second antibody to form an antibody heteroconjugate as described by Segal in U.S. Patent No. 4,676,980, which is incorporated herein by reference in its entirety.

The present invention also encompasses the creation of synthetic antibodies directed against the polypeptides of the present invention. One example of synthetic
15 antibodies is described in Radrizzani, M., et al., Medicina, (Aires), 59(6):753-8, (1999)). Recently, a new class of synthetic antibodies has been described and are referred to as molecularly imprinted polymers (MIPs) (Semorex, Inc.). Antibodies, peptides, and enzymes are often used as molecular recognition elements in chemical and biological sensors. However, their lack of stability and signal transduction
20 mechanisms limits their use as sensing devices. Molecularly imprinted polymers (MIPs) are capable of mimicking the function of biological receptors but with less stability constraints. Such polymers provide high sensitivity and selectivity while maintaining excellent thermal and mechanical stability. MIPs have the ability to bind to small molecules and to target molecules such as organics and proteins' with equal
25 or greater potency than that of natural antibodies. These "super" MIPs have higher affinities for their target and thus require lower concentrations for efficacious binding.

During synthesis, the MIPs are imprinted so as to have complementary size, shape, charge and functional groups of the selected target by using the target molecule itself (such as a polypeptide, antibody, etc.), or a substance having a very similar
30 structure, as its "print" or "template." MIPs can be derivatized with the same reagents afforded to antibodies. For example, fluorescent 'super' MIPs can be coated onto beads or wells for use in highly sensitive separations or assays, or for use in high throughput screening of proteins.

Moreover, MIPs based upon the structure of the polypeptide(s) of the present
35 invention may be useful in screening for compounds that bind to the polypeptide(s) of the invention. Such a MIP would serve the role of a synthetic "receptor" by

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5 minimicking the native architecture of the polypeptide. In fact, the ability of a MIP to serve the role of a synthetic receptor has already been demonstrated for the estrogen receptor (Ye, L., Yu, Y., Mosbach, K, *Analyst.*, 126(6):760-5, (2001); Dickert, F, L., Hayden, O., Halikias, K, P, *Analyst.*, 126(6):766-71, (2001)). A synthetic receptor may either be mimicked in its entirety (c.g., as the entire protein), or mimicked as a
10 series of short peptides corresponding to the protein (Rachkov, A., Minoura, N, *Biochim, Biophys, Acta.*, 1544(1-2):255-66, (2001)). Such a synthetic receptor MIPs may be employed in any one or more of the screening methods described elsewhere herein.

MIPs have also been shown to be useful in "sensing" the presence of its
15 mimicked molecule (Cheng, Z., Wang, E., Yang, X, *Biosens, Bioelectron.*, 16(3):179-85, (2001) ; Jenkins, A, L., Yin, R., Jensen, J. L, *Analyst.*, 126(6):798-802, (2001) ; Jenkins, A, L., Yin, R., Jensen, J. L, *Analyst.*, 126(6):798-802, (2001)). For example, a MIP designed using a polypeptide of the present invention may be used in assays designed to identify, and potentially quantitate, the level of said polypeptide in a
20 sample. Such a MIP may be used as a substitute for any component described in the assays, or kits, provided herein (e.g., ELISA, etc.).

A number of methods may be employed to create MIPs to a specific receptor, ligand, polypeptide, peptide, organic molecule. Several preferred methods are described by Esteban et al in *J. Anal, Chem.*, 370(7):795-802, (2001), which is hereby
25 incorporated herein by reference in its entirety in addition to any references cited therein. Additional methods are known in the art and are encompassed by the present invention, such as for example, Hart, B, R., Shea, K, J. J. *Am. Chem, Soc.*, 123(9):2072-3, (2001); and Quaglia, M., Chenon, K., Hall, A, J., De, Lorenzi, E., Sellergren, B, J. *Am. Chem, Soc.*, 123(10):2146-54, (2001); which are hereby
30 incorporated by reference in their entirety herein.

An antibody, with or without a therapeutic moiety conjugated to it, administered alone or in combination with cytotoxic factor(s) and/or cytokine(s) can be used as a therapeutic.

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Uses for Antibodies directed against polypeptides of the invention

The antibodies of the present invention have various utilities. For example, such antibodies may be used in diagnostic assays to detect the presence or quantification of the polypeptides of the invention in a sample. Such a diagnostic
10 assay may be comprised of at least two steps. The first, subjecting a sample with the antibody, wherein the sample is a tissue (e.g., human, animal, etc.), biological fluid (e.g., blood, urine, sputum, semen, amniotic fluid, saliva, etc.), biological extract (e.g., tissue or cellular homogenate, etc.), a protein microchip (e.g., See Arenkov P, et al., Anal Biochem., 278(2):123-131 (2000)), or a chromatography column, etc. And a
15 second step involving the quantification of antibody bound to the substrate. Alternatively, the method may additionally involve a first step of attaching the antibody, either covalently, electrostatically, or reversibly, to a solid support, and a second step of subjecting the bound antibody to the sample, as defined above and elsewhere herein.

20 Various diagnostic assay techniques are known in the art, such as competitive binding assays, direct or indirect sandwich assays and immunoprecipitation assays conducted in either heterogeneous or homogenous phases (Zola, Monoclonal Antibodies: A Manual of Techniques, CRC Press, Inc., (1987), pp147-158). The antibodies used in the diagnostic assays can be labeled with a detectable moiety. The
25 detectable moiety should be capable of producing, either directly or indirectly, a detectable signal. For example, the detectable moiety may be a radioisotope, such as ²H, ¹⁴C, ³²P, or ¹²⁵I, a florescent or chemiluminescent compound, such as fluorescein isothiocyanate, rhodamine, or luciferin, or an enzyme, such as alkaline phosphatase, beta-galactosidase, green fluorescent protein, or horseradish peroxidase.
30 Any method known in the art for conjugating the antibody to the detectable moiety may be employed, including those methods described by Hunter et al., Nature, 144:945 (1962); Dafvid et al., Biochem., 13:1014 (1974); Pain et al., J. Immunol. Metho., 40:219(1981); and Nygren, J. Histochem. And Cytochem., 30:407 (1982).

Antibodies directed against the polypeptides of the present invention are
35 useful for the affinity purification of such polypeptides from recombinant cell culture or natural sources. In this process, the antibodies against a particular polypeptide are

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5 immobilized on a suitable support, such as a Sephadex resin or filter paper, using methods well known in the art. The immobilized antibody then is contacted with a sample containing the polypeptides to be purified, and thereafter the support is washed with a suitable solvent that will remove substantially all the material in the sample except for the desired polypeptides, which are bound to the immobilized
10 antibody. Finally, the support is washed with another suitable solvent that will release the desired polypeptide from the antibody.

Immunophenotyping

The antibodies of the invention may be utilized for immunophenotyping of
15 cell lines and biological samples. The translation product of the gene of the present invention may be useful as a cell specific marker, or more specifically as a cellular marker that is differentially expressed at various stages of differentiation and/or maturation of particular cell types. Monoclonal antibodies directed against a specific epitope, or combination of epitopes, will allow for the screening of cellular
20 populations expressing the marker. Various techniques can be utilized using monoclonal antibodies to screen for cellular populations expressing the marker(s), and include magnetic separation using antibody-coated magnetic beads, "panning" with antibody attached to a solid matrix (i.e., plate), and flow cytometry (See, e.g., U.S. Patent 5,985,660; and Morrison et al., Cell, 96:737-49 (1999)).

25 These techniques allow for the screening of particular populations of cells, such as might be found with hematological malignancies (i.e. minimal residual disease (MRD) in acute leukemic patients) and "non-self" cells in transplantations to prevent Graft-versus-Host Disease (GVHD). Alternatively, these techniques allow for the screening of hematopoietic stem and progenitor cells capable of undergoing
30 proliferation and/or differentiation, as might be found in human umbilical cord blood.

Assays For Antibody Binding

The antibodies of the invention may be assayed for immunospecific binding by any method known in the art. The immunoassays which can be used include but
35 are not limited to competitive and non-competitive assay systems using techniques such as western blots, radioimmunoassays, ELISA (enzyme linked immunosorbent

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5 assay), "sandwich" immunoassays, immunoprecipitation assays, precipitin reactions, gel diffusion precipitin reactions, immunodiffusion assays, agglutination assays, complement-fixation assays, immunoradiometric assays, fluorescent immunoassays, protein A immunoassays, to name but a few. Such assays are routine and well known in the art (see, e.g., Ausubel et al, eds, 1994, Current Protocols in Molecular Biology, 10 Vol. 1, John Wiley & Sons, Inc., New York, which is incorporated by reference herein in its entirety). Exemplary immunoassays are described briefly below (but are not intended by way of limitation).

Immunoprecipitation protocols generally comprise lysing a population of cells in a lysis buffer such as RIPA buffer (1% NP-40 or Triton X- 100, 1% sodium deoxycholate, 0.1% SDS, 0.15 M NaCl, 0.01 M sodium phosphate at pH 7.2, 1% 15 Trasylol) supplemented with protein phosphatase and/or protease inhibitors (e.g., EDTA, PMSF, aprotinin, sodium vanadate), adding the antibody of interest to the cell lysate, incubating for a period of time (e.g., 1-4 hours) at 4° C, adding protein A and/or protein G sepharose beads to the cell lysate, incubating for about an hour or 20 more at 4° C, washing the beads in lysis buffer and resuspending the beads in SDS/sample buffer. The ability of the antibody of interest to immunoprecipitate a particular antigen can be assessed by, e.g., western blot analysis. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the binding of the antibody to an antigen and decrease the background (e.g., pre-clearing 25 the cell lysate with sepharose beads). For further discussion regarding immunoprecipitation protocols see, e.g., Ausubel et al, eds, 1994, Current Protocols in Molecular Biology, Vol. 1, John Wiley & Sons, Inc., New York at 10.16.1.

Western blot analysis generally comprises preparing protein samples, electrophoresis of the protein samples in a polyacrylamide gel (e.g., 8%- 20% SDS- 30 PAGE depending on the molecular weight of the antigen), transferring the protein sample from the polyacrylamide gel to a membrane such as nitrocellulose, PVDF or nylon, blocking the membrane in blocking solution (e.g., PBS with 3% BSA or non-fat milk), washing the membrane in washing buffer (e.g., PBS-Tween 20), blocking the membrane with primary antibody (the antibody of interest) diluted in blocking 35 buffer, washing the membrane in washing buffer, blocking the membrane with a secondary antibody (which recognizes the primary antibody, e.g., an anti-human

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5 antibody) conjugated to an enzymatic substrate (e.g., horseradish peroxidase or alkaline phosphatase) or radioactive molecule (e.g., ^{32}P or ^{125}I) diluted in blocking buffer, washing the membrane in wash buffer, and detecting the presence of the antigen. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the signal detected and to reduce the background noise. For
10 further discussion regarding western blot protocols see, e.g., Ausubel et al, eds, 1994, Current Protocols in Molecular Biology, Vol. 1, John Wiley & Sons, Inc., New York at 10.8.1.

ELISAs comprise preparing antigen, coating the well of a 96 well microtiter plate with the antigen, adding the antibody of interest conjugated to a detectable
15 compound such as an enzymatic substrate (e.g., horseradish peroxidase or alkaline phosphatase) to the well and incubating for a period of time, and detecting the presence of the antigen. In ELISAs the antibody of interest does not have to be conjugated to a detectable compound; instead, a second antibody (which recognizes the antibody of interest) conjugated to a detectable compound may be added to the
20 well. Further, instead of coating the well with the antigen, the antibody may be coated to the well. In this case, a second antibody conjugated to a detectable compound may be added following the addition of the antigen of interest to the coated well. One of skill in the art would be knowledgeable as to the parameters that can be modified to increase the signal detected as well as other variations of ELISAs known in the art.
25 For further discussion regarding ELISAs see, e.g., Ausubel et al, eds, 1994, Current Protocols in Molecular Biology, Vol. 1, John Wiley & Sons, Inc., New York at 11.2.1.

The binding affinity of an antibody to an antigen and the off-rate of an antibody-antigen interaction can be determined by competitive binding assays. One
30 example of a competitive binding assay is a radioimmunoassay comprising the incubation of labeled antigen (e.g., ^3H or ^{125}I) with the antibody of interest in the presence of increasing amounts of unlabeled antigen, and the detection of the antibody bound to the labeled antigen. The affinity of the antibody of interest for a particular antigen and the binding off-rates can be determined from the data by
35 scatchard plot analysis. Competition with a second antibody can also be determined using radioimmunoassays. In this case, the antigen is incubated with antibody of

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- 5 interest conjugated to a labeled compound (e.g., ^3H or ^{125}I) in the presence of increasing amounts of an unlabeled second antibody.

Therapeutic Uses Of Antibodies

The present invention is further directed to antibody-based therapies which
 10 involve administering antibodies of the invention to an animal, preferably a mammal, and most preferably a human, patient for treating one or more of the disclosed diseases, disorders, or conditions. Therapeutic compounds of the invention include, but are not limited to, antibodies of the invention (including fragments, analogs and derivatives thereof as described herein) and nucleic acids encoding antibodies of the
 15 invention (including fragments, analogs and derivatives thereof and anti-idiotypic antibodies as described herein). The antibodies of the invention can be used to treat, inhibit or prevent diseases, disorders or conditions associated with aberrant expression and/or activity of a polypeptide of the invention, including, but not limited to, any one or more of the diseases, disorders, or conditions described herein. The treatment
 20 and/or prevention of diseases, disorders, or conditions associated with aberrant expression and/or activity of a polypeptide of the invention includes, but is not limited to, alleviating symptoms associated with those diseases, disorders or conditions. Antibodies of the invention may be provided in pharmaceutically acceptable compositions as known in the art or as described herein.

25 A summary of the ways in which the antibodies of the present invention may be used therapeutically includes binding polynucleotides or polypeptides of the present invention locally or systemically in the body or by direct cytotoxicity of the antibody, e.g. as mediated by complement (CDC) or by effector cells (ADCC). Some of these approaches are described in more detail below. Armed with the teachings
 30 provided herein, one of ordinary skill in the art will know how to use the antibodies of the present invention for diagnostic, monitoring or therapeutic purposes without undue experimentation.

The antibodies of this invention may be advantageously utilized in combination with other monoclonal or chimeric antibodies, or with lymphokines or
 35 hematopoietic growth factors (such as, e.g., IL-2, IL-3 and IL-7), for example, which serve to increase the number or activity of effector cells which interact with the

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5 antibodies.

The antibodies of the invention may be administered alone or in combination with other types of treatments (e.g., radiation therapy, chemotherapy, hormonal therapy, immunotherapy and anti-tumor agents). Generally, administration of products of a species origin or species reactivity (in the case of antibodies) that is the same species as that of the patient is preferred. Thus, in a preferred embodiment, human antibodies, fragments derivatives, analogs, or nucleic acids, are administered to a human patient for therapy or prophylaxis.

It is preferred to use high affinity and/or potent in vivo inhibiting and/or neutralizing antibodies against polypeptides or polynucleotides of the present invention, fragments or regions thereof, for both immunoassays directed to and therapy of disorders related to polynucleotides or polypeptides, including fragments thereof, of the present invention. Such antibodies, fragments, or regions, will preferably have an affinity for polynucleotides or polypeptides of the invention, including fragments thereof. Preferred binding affinities include those with a dissociation constant or K_d less than 5×10^{-2} M, 10^{-2} M, 5×10^{-3} M, 10^{-3} M, 5×10^{-4} M, 10^{-4} M, 5×10^{-5} M, 10^{-5} M, 5×10^{-6} M, 10^{-6} M, 5×10^{-7} M, 10^{-7} M, 5×10^{-8} M, 10^{-8} M, 5×10^{-9} M, 10^{-9} M, 5×10^{-10} M, 10^{-10} M, 5×10^{-11} M, 10^{-11} M, 5×10^{-12} M, 10^{-12} M, 5×10^{-13} M, 10^{-13} M, 5×10^{-14} M, 10^{-14} M, 5×10^{-15} M, and 10^{-15} M.

Antibodies directed against polypeptides of the present invention are useful for inhibiting allergic reactions in animals. For example, by administering a therapeutically acceptable dose of an antibody, or antibodies, of the present invention, or a cocktail of the present antibodies, or in combination with other antibodies of varying sources, the animal may not elicit an allergic response to antigens.

Likewise, one could envision cloning the gene encoding an antibody directed against a polypeptide of the present invention, said polypeptide having the potential to elicit an allergic and/or immune response in an organism, and transforming the organism with said antibody gene such that it is expressed (e.g., constitutively, inducibly, etc.) in the organism. Thus, the organism would effectively become resistant to an allergic response resulting from the ingestion or presence of such an immune/allergic reactive polypeptide. Moreover, such a use of the antibodies of the

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5 present invention may have particular utility in preventing and/or ameliorating autoimmune diseases and/or disorders, as such conditions are typically a result of antibodies being directed against endogenous proteins. For example, in the instance where the polypeptide of the present invention is responsible for modulating the immune response to auto-antigens, transforming the organism and/or individual with
10 a construct comprising any of the promoters disclosed herein or otherwise known in the art, in addition, to a polynucleotide encoding the antibody directed against the polypeptide of the present invention could effective inhibit the organisms immune system from eliciting an immune response to the auto-antigen(s). Detailed descriptions of therapeutic and/or gene therapy applications of the present invention
15 are provided elsewhere herein.

Alternatively, antibodies of the present invention could be produced in a plant (e.g., cloning the gene of the antibody directed against a polypeptide of the present invention, and transforming a plant with a suitable vector comprising said gene for constitutive expression of the antibody within the plant), and the plant subsequently
20 ingested by an animal, thereby conferring temporary immunity to the animal for the specific antigen the antibody is directed towards (See, for example, US Patent Nos. 5,914,123 and 6,034,298).

In another embodiment, antibodies of the present invention, preferably polyclonal antibodies, more preferably monoclonal antibodies, and most preferably
25 single-chain antibodies, can be used as a means of inhibiting gene expression of a particular gene, or genes, in a human, mammal, and/or other organism. See, for example, International Publication Number WO 00/05391, published 2/3/00, to Dow Agrosiences LLC. The application of such methods for the antibodies of the present invention are known in the art, and are more particularly described elsewhere herein.

30 In yet another embodiment, antibodies of the present invention may be useful for multimerizing the polypeptides of the present invention. For example, certain proteins may confer enhanced biological activity when present in a multimeric state (i.e., such enhanced activity may be due to the increased effective concentration of such proteins whereby more protein is available in a localized location).

35

Antibody-based Gene Therapy

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5 In a specific embodiment, nucleic acids comprising sequences encoding antibodies or functional derivatives thereof, are administered to treat, inhibit or prevent a disease or disorder associated with aberrant expression and/or activity of a polypeptide of the invention, by way of gene therapy. Gene therapy refers to therapy performed by the administration to a subject of an expressed or expressible nucleic acid. In this embodiment of the invention, the nucleic acids produce their encoded protein that mediates a therapeutic effect.

Any of the methods for gene therapy available in the art can be used according to the present invention. Exemplary methods are described below.

For general reviews of the methods of gene therapy, see Goldspiel et al.,
 15 Clinical Pharmacy 12:488-505 (1993); Wu and Wu, Biotherapy 3:87-95 (1991); Tolstoshev, Ann. Rev. Pharmacol. Toxicol. 32:573-596 (1993); Mulligan, Science 260:926-932 (1993); and Morgan and Anderson, Ann. Rev. Biochem. 62:191-217 (1993); May, TIBTECH 11(5):155-215 (1993). Methods commonly known in the art of recombinant DNA technology which can be used are described in Ausubel et al.
 20 (cds.), Current Protocols in Molecular Biology, John Wiley & Sons, NY (1993); and Kriegler, Gene Transfer and Expression, A Laboratory Manual, Stockton Press, NY (1990).

In a preferred aspect, the compound comprises nucleic acid sequences encoding an antibody, said nucleic acid sequences being part of expression vectors
 25 that express the antibody or fragments or chimeric proteins or heavy or light chains thereof in a suitable host. In particular, such nucleic acid sequences have promoters operably linked to the antibody coding region, said promoter being inducible or constitutive, and, optionally, tissue- specific. In another particular embodiment, nucleic acid molecules are used in which the antibody coding sequences and any other
 30 desired sequences are flanked by regions that promote homologous recombination at a desired site in the genome, thus providing for intrachromosomal expression of the antibody encoding nucleic acids (Koller and Smithies, Proc. Natl. Acad. Sci. USA 86:8932-8935 (1989); Zijlstra et al., Nature 342:435-438 (1989). In specific embodiments, the expressed antibody molecule is a single chain antibody;
 35 alternatively, the nucleic acid sequences include sequences encoding both the heavy and light chains, or fragments thereof, of the antibody.

5 Delivery of the nucleic acids into a patient may be either direct, in which case the patient is directly exposed to the nucleic acid or nucleic acid- carrying vectors, or indirect, in which case, cells are first transformed with the nucleic acids in vitro, then transplanted into the patient. These two approaches are known, respectively, as in vivo or ex vivo gene therapy.

10 In a specific embodiment, the nucleic acid sequences are directly administered in vivo, where it is expressed to produce the encoded product. This can be accomplished by any of numerous methods known in the art, e.g., by constructing them as part of an appropriate nucleic acid expression vector and administering it so that they become intracellular, e.g., by infection using defective or attenuated
15 retrovirals or other viral vectors (see U.S. Patent No. 4,980,286), or by direct injection of naked DNA, or by use of microparticle bombardment (e.g., a gene gun; Biolistic, Dupont), or coating with lipids or cell-surface receptors or transfecting agents, encapsulation in liposomes, microparticles, or microcapsules, or by administering them in linkage to a peptide which is known to enter the nucleus, by administering it
20 in linkage to a ligand subject to receptor-mediated endocytosis (see, e.g., Wu and Wu, J. Biol. Chem... 262:4429-4432 (1987)) (which can be used to target cell types specifically expressing the receptors), etc. In another embodiment, nucleic acid-ligand complexes can be formed in which the ligand comprises a fusogenic viral peptide to disrupt endosomes, allowing the nucleic acid to avoid lysosomal degradation. In yet
25 another embodiment, the nucleic acid can be targeted in vivo for cell specific uptake and expression, by targeting a specific receptor (see, e.g., PCT Publications WO 92/06180; WO 92/22635; WO92/20316; WO93/14188, WO 93/20221). Alternatively, the nucleic acid can be introduced intracellularly and incorporated within host cell DNA for expression, by homologous recombination (Koller and Smithies, Proc. Natl.
30 Acad. Sci. USA 86:8932-8935 (1989); Zijlstra et al., Nature 342:435-438 (1989)).

 In a specific embodiment, viral vectors that contains nucleic acid sequences encoding an antibody of the invention are used. For example, a retroviral vector can be used (see Miller et al., Meth. Enzymol. 217:581-599 (1993)). These retroviral vectors contain the components necessary for the correct packaging of the viral
35 genome and integration into the host cell DNA. The nucleic acid sequences encoding the antibody to be used in gene therapy are cloned into one or more vectors, which

5 facilitates delivery of the gene into a patient. More detail about retroviral vectors can be found in Boesen et al., *Biotherapy* 6:291-302 (1994), which describes the use of a retroviral vector to deliver the *mdr1* gene to hematopoietic stem cells in order to make the stem cells more resistant to chemotherapy. Other references illustrating the use of retroviral vectors in gene therapy are: Clowes et al., *J. Clin. Invest.* 93:644-651
10 (1994); Kiem et al., *Blood* 83:1467-1473 (1994); Salmons and Gunzberg, *Human Gene Therapy* 4:129-141 (1993); and Grossman and Wilson, *Curr. Opin. in Genetics and Devel.* 3:110-114 (1993).

Adenoviruses are other viral vectors that can be used in gene therapy. Adenoviruses are especially attractive vehicles for delivering genes to respiratory
15 epithelia. Adenoviruses naturally infect respiratory epithelia where they cause a mild disease. Other targets for adenovirus-based delivery systems are liver, the central nervous system, endothelial cells, and muscle. Adenoviruses have the advantage of being capable of infecting non-dividing cells. Kozarsky and Wilson, *Current Opinion in Genetics and Development* 3:499-503 (1993) present a review of adenovirus-based
20 gene therapy. Bout et al., *Human Gene Therapy* 5:3-10 (1994) demonstrated the use of adenovirus vectors to transfer genes to the respiratory epithelia of rhesus monkeys. Other instances of the use of adenoviruses in gene therapy can be found in Rosenfeld et al., *Science* 252:431-434 (1991); Rosenfeld et al., *Cell* 68:143- 155 (1992); Mastrangeli et al., *J. Clin. Invest.* 91:225-234 (1993); PCT Publication WO94/12649;
25 and Wang, et al., *Gene Therapy* 2:775-783 (1995). In a preferred embodiment, adenovirus vectors are used.

Adeno-associated virus (AAV) has also been proposed for use in gene therapy (Walsh et al., *Proc. Soc. Exp. Biol. Med.* 204:289-300 (1993); U.S. Patent No. 5,436,146).

30 Another approach to gene therapy involves transferring a gene to cells in tissue culture by such methods as electroporation, lipofection, calcium phosphate mediated transfection, or viral infection. Usually, the method of transfer includes the transfer of a selectable marker to the cells. The cells are then placed under selection to isolate those cells that have taken up and are expressing the transferred gene. Those
35 cells are then delivered to a patient.

In this embodiment, the nucleic acid is introduced into a cell prior to

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5 administration in vivo of the resulting recombinant cell. Such introduction can be carried out by any method known in the art, including but not limited to transfection, electroporation, microinjection, infection with a viral or bacteriophage vector containing the nucleic acid sequences, cell fusion, chromosome-mediated gene transfer, microcell-mediated gene transfer, spheroplast fusion, etc. Numerous techniques are known in the art for the introduction of foreign genes into cells (see, 10 e.g., Loeffler and Behr, Meth. Enzymol. 217:599-618 (1993); Cohen et al., Meth. Enzymol. 217:618-644 (1993); Cline, Pharmac. Ther. 29:69-92m (1985) and may be used in accordance with the present invention, provided that the necessary developmental and physiological functions of the recipient cells are not disrupted. The technique should provide for the stable transfer of the nucleic acid to the cell, so that 15 the nucleic acid is expressible by the cell and preferably heritable and expressible by its cell progeny.

The resulting recombinant cells can be delivered to a patient by various methods known in the art. Recombinant blood cells (e.g., hematopoietic stem or 20 progenitor cells) are preferably administered intravenously. The amount of cells envisioned for use depends on the desired effect, patient state, etc., and can be determined by one skilled in the art.

Cells into which a nucleic acid can be introduced for purposes of gene therapy encompass any desired, available cell type, and include but are not limited to 25 epithelial cells, endothelial cells, keratinocytes, fibroblasts, muscle cells, hepatocytes; blood cells such as Tlymphocytes, Blymphocytes, monocytes, macrophages, neutrophils, eosinophils, megakaryocytes, granulocytes; various stem or progenitor cells, in particular hematopoietic stem or progenitor cells, e.g., as obtained from bone marrow, umbilical cord blood, peripheral blood, fetal liver, etc.

30 In a preferred embodiment, the cell used for gene therapy is autologous to the patient.

In an embodiment in which recombinant cells are used in gene therapy, nucleic acid sequences encoding an antibody are introduced into the cells such that they are expressible by the cells or their progeny, and the recombinant cells are then 35 administered in vivo for therapeutic effect. In a specific embodiment, stem or progenitor cells are used. Any stem and/or progenitor cells which can be isolated and

5 maintained in vitro can potentially be used in accordance with this embodiment of the present invention (see e.g. PCT Publication WO 94/08598; Stemple and Anderson, Cell 71:973-985 (1992); Rheinwald, Meth. Cell Bio. 21A:229 (1980); and Pittelkow and Scott, Mayo Clinic Proc. 61:771 (1986)).

10 In a specific embodiment, the nucleic acid to be introduced for purposes of gene therapy comprises an inducible promoter operably linked to the coding region, such that expression of the nucleic acid is controllable by controlling the presence or absence of the appropriate inducer of transcription. Demonstration of Therapeutic or Prophylactic Activity

15 The compounds or pharmaceutical compositions of the invention are preferably tested in vitro, and then in vivo for the desired therapeutic or prophylactic activity, prior to use in humans. For example, in vitro assays to demonstrate the therapeutic or prophylactic utility of a compound or pharmaceutical composition include, the effect of a compound on a cell line or a patient tissue sample. The effect of the compound or composition on the cell line and/or tissue sample can be
20 determined utilizing techniques known to those of skill in the art including, but not limited to, rosette formation assays and cell lysis assays. In accordance with the invention, in vitro assays which can be used to determine whether administration of a specific compound is indicated, include in vitro cell culture assays in which a patient tissue sample is grown in culture, and exposed to or otherwise administered a
25 compound, and the effect of such compound upon the tissue sample is observed.

Therapeutic/Prophylactic Administration and Compositions

30 The invention provides methods of treatment, inhibition and prophylaxis by administration to a subject of an effective amount of a compound or pharmaceutical composition of the invention, preferably an antibody of the invention. In a preferred aspect, the compound is substantially purified (e.g., substantially free from substances that limit its effect or produce undesired side-effects). The subject is preferably an animal, including but not limited to animals such as cows, pigs, horses, chickens, cats, dogs, etc., and is preferably a mammal, and most preferably human.

35 Formulations and methods of administration that can be employed when the compound comprises a nucleic acid or an immunoglobulin are described above;

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5 additional appropriate formulations and routes of administration can be selected from among those described herein below.

Various delivery systems are known and can be used to administer a compound of the invention, e.g., encapsulation in liposomes, microparticles, microcapsules, recombinant cells capable of expressing the compound, receptor-mediated endocytosis (see, e.g., Wu and Wu, J. Biol. Chem.. 262:4429-4432 (1987)),
 10 construction of a nucleic acid as part of a retroviral or other vector, etc. Methods of introduction include but are not limited to intradermal, intramuscular, intraperitoneal, intravenous, subcutaneous, intranasal, epidural, and oral routes. The compounds or compositions may be administered by any convenient route, for example by infusion
 15 or bolus injection, by absorption through epithelial or mucocutaneous linings (e.g., oral mucosa, rectal and intestinal mucosa, etc.) and may be administered together with other biologically active agents. Administration can be systemic or local. In addition, it may be desirable to introduce the pharmaceutical compounds or compositions of the invention into the central nervous system by any suitable route, including
 20 intraventricular and intrathecal injection; intraventricular injection may be facilitated by an intraventricular catheter, for example, attached to a reservoir, such as an Ommaya reservoir. Pulmonary administration can also be employed, e.g., by use of an inhaler or nebulizer, and formulation with an aerosolizing agent.

In a specific embodiment, it may be desirable to administer the pharmaceutical
 25 compounds or compositions of the invention locally to the area in need of treatment; this may be achieved by, for example, and not by way of limitation, local infusion during surgery, topical application, e.g., in conjunction with a wound dressing after surgery, by injection, by means of a catheter, by means of a suppository, or by means of an implant, said implant being of a porous, non-porous, or gelatinous material,
 30 including membranes, such as sialastic membranes, or fibers. Preferably, when administering a protein, including an antibody, of the invention, care must be taken to use materials to which the protein does not absorb.

In another embodiment, the compound or composition can be delivered in a vesicle, in particular a liposome (see Langer, Science 249:1527-1533 (1990); Treat et al., in Liposomes in the Therapy of Infectious Disease and Cancer, Lopez-Berestein
 35 and Fidler (eds.), Liss, New York, pp. 353- 365 (1989); Lopez-Berestein, ibid., pp.

5 317-327; see generally *ibid.*)

In yet another embodiment, the compound or composition can be delivered in a controlled release system. In one embodiment, a pump may be used (see Langer, *supra*; Sefton, *CRC Crit. Ref. Biomed. Eng.* 14:201 (1987); Buchwald et al., *Surgery* 88:507 (1980); Saudek et al., *N. Engl. J. Med.* 321:574 (1989)). In another
10 embodiment, polymeric materials can be used (see *Medical Applications of Controlled Release*, Langer and Wise (eds.), CRC Pres., Boca Raton, Florida (1974); *Controlled Drug Bioavailability, Drug Product Design and Performance*, Smolen and Ball (eds.), Wiley, New York (1984); Ranger and Peppas, J., *Macromol. Sci. Rev. Macromol. Chem.* 23:61 (1983); see also Levy et al., *Science* 228:190 (1985); During
15 et al., *Ann. Neurol.* 25:351 (1989); Howard et al., *J. Neurosurg.* 71:105 (1989)). In yet another embodiment, a controlled release system can be placed in proximity of the therapeutic target, i.e., the brain, thus requiring only a fraction of the systemic dose (see, e.g., Goodson, in *Medical Applications of Controlled Release*, *supra*, vol. 2, pp. 115-138 (1984)).

20 Other controlled release systems are discussed in the review by Langer (*Science* 249:1527-1533 (1990)).

In a specific embodiment where the compound of the invention is a nucleic acid encoding a protein, the nucleic acid can be administered *in vivo* to promote expression of its encoded protein, by constructing it as part of an appropriate nucleic
25 acid expression vector and administering it so that it becomes intracellular, e.g., by use of a retroviral vector (see U.S. Patent No. 4,980,286), or by direct injection, or by use of microparticle bombardment (e.g., a gene gun; Biolistic, Dupont), or coating with lipids or cell-surface receptors or transfecting agents, or by administering it in linkage to a homeobox-like peptide which is known to enter the nucleus (see e.g.,
30 Joliot et al., *Proc. Natl. Acad. Sci. USA* 88:1864-1868 (1991)), etc. Alternatively, a nucleic acid can be introduced intracellularly and incorporated within host cell DNA for expression, by homologous recombination.

The present invention also provides pharmaceutical compositions. Such compositions comprise a therapeutically effective amount of a compound, and a
35 pharmaceutically acceptable carrier. In a specific embodiment, the term "pharmaceutically acceptable" means approved by a regulatory agency of the Federal

5 or a state government or listed in the U.S. Pharmacopeia or other generally recognized pharmacopeia for use in animals, and more particularly in humans. The term "carrier" refers to a diluent, adjuvant, excipient, or vehicle with which the therapeutic is administered. Such pharmaceutical carriers can be sterile liquids, such as water and oils, including those of petroleum, animal, vegetable or synthetic origin, such as
10 peanut oil, soybean oil, mineral oil, sesame oil and the like. Water is a preferred carrier when the pharmaceutical composition is administered intravenously. Saline solutions and aqueous dextrose and glycerol solutions can also be employed as liquid carriers, particularly for injectable solutions. Suitable pharmaceutical excipients include starch, glucose, lactose, sucrose, gelatin, malt, rice, flour, chalk, silica gel,
15 sodium stearate, glycerol monostearate, talc, sodium chloride, dried skim milk, glycerol, propylene, glycol, water, ethanol and the like. The composition, if desired, can also contain minor amounts of wetting or emulsifying agents, or pH buffering agents. These compositions can take the form of solutions, suspensions, emulsion, tablets, pills, capsules, powders, sustained-release formulations and the like. The
20 composition can be formulated as a suppository, with traditional binders and carriers such as triglycerides. Oral formulation can include standard carriers such as pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, etc. Examples of suitable pharmaceutical carriers are described in "Remington's Pharmaceutical Sciences" by E.W. Martin.
25 Such compositions will contain a therapeutically effective amount of the compound, preferably in purified form, together with a suitable amount of carrier so as to provide the form for proper administration to the patient. The formulation should suit the mode of administration.

In a preferred embodiment, the composition is formulated in accordance with
30 routine procedures as a pharmaceutical composition adapted for intravenous administration to human beings. Typically, compositions for intravenous administration are solutions in sterile isotonic aqueous buffer. Where necessary, the composition may also include a solubilizing agent and a local anesthetic such as lignocaine to ease pain at the site of the injection. Generally, the ingredients are
35 supplied either separately or mixed together in unit dosage form, for example, as a dry lyophilized powder or water free concentrate in a hermetically sealed container such

5 as an ampoule or sachette indicating the quantity of active agent. Where the composition is to be administered by infusion, it can be dispensed with an infusion bottle containing sterile pharmaceutical grade water or saline. Where the composition is administered by injection, an ampoule of sterile water for injection or saline can be provided so that the ingredients may be mixed prior to administration.

10 The compounds of the invention can be formulated as neutral or salt forms. Pharmaceutically acceptable salts include those formed with anions such as those derived from hydrochloric, phosphoric, acetic, oxalic, tartaric acids, etc., and those formed with cations such as those derived from sodium, potassium, ammonium, calcium, ferric hydroxides, isopropylamine, triethylamine, 2-ethylamino ethanol, 15 histidine, procaine, etc.

The amount of the compound of the invention which will be effective in the treatment, inhibition and prevention of a disease or disorder associated with aberrant expression and/or activity of a polypeptide of the invention can be determined by standard clinical techniques. In addition, in vitro assays may optionally be employed 20 to help identify optimal dosage ranges. The precise dose to be employed in the formulation will also depend on the route of administration, and the seriousness of the disease or disorder, and should be decided according to the judgment of the practitioner and each patient's circumstances. Effective doses may be extrapolated from dose-response curves derived from in vitro or animal model test systems.

25 For antibodies, the dosage administered to a patient is typically 0.1 mg/kg to 100 mg/kg of the patient's body weight. Preferably, the dosage administered to a patient is between 0.1 mg/kg and 20 mg/kg of the patient's body weight, more preferably 1 mg/kg to 10 mg/kg of the patient's body weight. Generally, human antibodies have a longer half-life within the human body than antibodies from other 30 species due to the immune response to the foreign polypeptides. Thus, lower dosages of human antibodies and less frequent administration is often possible. Further, the dosage and frequency of administration of antibodies of the invention may be reduced by enhancing uptake and tissue penetration (e.g., into the brain) of the antibodies by modifications such as, for example, lipidation.

35 The invention also provides a pharmaceutical pack or kit comprising one or more containers filled with one or more of the ingredients of the pharmaceutical

5 compositions of the invention. Optionally associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration.

10 *Diagnosis and Imaging With Antibodies*

Labeled antibodies, and derivatives and analogs thereof, which specifically bind to a polypeptide of interest can be used for diagnostic purposes to detect, diagnose, or monitor diseases, disorders, and/or conditions associated with the aberrant expression and/or activity of a polypeptide of the invention. The invention provides for the detection of aberrant expression of a polypeptide of interest, comprising (a) assaying the expression of the polypeptide of interest in cells or body fluid of an individual using one or more antibodies specific to the polypeptide interest and (b) comparing the level of gene expression with a standard gene expression level, whereby an increase or decrease in the assayed polypeptide gene expression level compared to the standard expression level is indicative of aberrant expression.

The invention provides a diagnostic assay for diagnosing a disorder, comprising (a) assaying the expression of the polypeptide of interest in cells or body fluid of an individual using one or more antibodies specific to the polypeptide interest and (b) comparing the level of gene expression with a standard gene expression level, whereby an increase or decrease in the assayed polypeptide gene expression level compared to the standard expression level is indicative of a particular disorder. With respect to cancer, the presence of a relatively high amount of transcript in biopsied tissue from an individual may indicate a predisposition for the development of the disease, or may provide a means for detecting the disease prior to the appearance of actual clinical symptoms. A more definitive diagnosis of this type may allow health professionals to employ preventative measures or aggressive treatment earlier thereby preventing the development or further progression of the cancer.

Antibodies of the invention can be used to assay protein levels in a biological sample using classical immunohistological methods known to those of skill in the art (e.g., see Jalkanen, et al., J. Cell. Biol. 101:976-985 (1985); Jalkanen, et al., J. Cell Biol. 105:3087-3096 (1987)). Other antibody-based methods useful for detecting

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5 protein gene expression include immunoassays, such as the enzyme linked immunosorbent assay (ELISA) and the radioimmunoassay (RIA). Suitable antibody assay labels are known in the art and include enzyme labels, such as, glucose oxidase; radioisotopes, such as iodine (^{125}I , ^{121}I), carbon (^{14}C), sulfur (^{35}S), tritium (^3H), indium (^{112}In), and technetium (^{99}Tc); luminescent labels, such as luminol; and
10 fluorescent labels, such as fluorescein and rhodamine, and biotin.

One aspect of the invention is the detection and diagnosis of a disease or disorder associated with aberrant expression of a polypeptide of interest in an animal, preferably a mammal and most preferably a human. In one embodiment, diagnosis comprises: a) administering (for example, parenterally, subcutaneously, or
15 intraperitoneally) to a subject an effective amount of a labeled molecule which specifically binds to the polypeptide of interest; b) waiting for a time interval following the administering for permitting the labeled molecule to preferentially concentrate at sites in the subject where the polypeptide is expressed (and for unbound labeled molecule to be cleared to background level); c) determining
20 background level; and d) detecting the labeled molecule in the subject, such that detection of labeled molecule above the background level indicates that the subject has a particular disease or disorder associated with aberrant expression of the polypeptide of interest. Background level can be determined by various methods including, comparing the amount of labeled molecule detected to a standard value
25 previously determined for a particular system.

It will be understood in the art that the size of the subject and the imaging system used will determine the quantity of imaging moiety needed to produce diagnostic images. In the case of a radioisotope moiety, for a human subject, the quantity of radioactivity injected will normally range from about 5 to 20 millicuries of
30 ^{99}mTc . The labeled antibody or antibody fragment will then preferentially accumulate at the location of cells which contain the specific protein. In vivo tumor imaging is described in S.W. Burchiel et al., "Immunopharmacokinetics of Radiolabeled Antibodies and Their Fragments." (Chapter 13 in Tumor Imaging: The Radiochemical Detection of Cancer, S.W. Burchiel and B. A. Rhodes, eds., Masson
35 Publishing Inc. (1982).

Depending on several variables, including the type of label used and the mode

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5 of administration, the time interval following the administration for permitting the labeled molecule to preferentially concentrate at sites in the subject and for unbound labeled molecule to be cleared to background level is 6 to 48 hours or 6 to 24 hours or 6 to 12 hours. In another embodiment the time interval following administration is 5 to 20 days or 5 to 10 days.

10 In an embodiment, monitoring of the disease or disorder is carried out by repeating the method for diagnosing the disease or disease, for example, one month after initial diagnosis, six months after initial diagnosis, one year after initial diagnosis, etc.

Presence of the labeled molecule can be detected in the patient using methods
15 known in the art for in vivo scanning. These methods depend upon the type of label used. Skilled artisans will be able to determine the appropriate method for detecting a particular label. Methods and devices that may be used in the diagnostic methods of the invention include, but are not limited to, computed tomography (CT), whole body scan such as position emission tomography (PET), magnetic resonance imaging
20 (MRI), and sonography.

In a specific embodiment, the molecule is labeled with a radioisotope and is detected in the patient using a radiation responsive surgical instrument (Thurston et al., U.S. Patent No. 5,441,050). In another embodiment, the molecule is labeled with a fluorescent compound and is detected in the patient using a fluorescence responsive
25 scanning instrument. In another embodiment, the molecule is labeled with a positron emitting metal and is detected in the patient using positron emission-tomography. In yet another embodiment, the molecule is labeled with a paramagnetic label and is detected in a patient using magnetic resonance imaging (MRI).

Kits

30 The present invention provides kits that can be used in the above methods. In one embodiment, a kit comprises an antibody of the invention, preferably a purified antibody, in one or more containers. In a specific embodiment, the kits of the present invention contain a substantially isolated polypeptide comprising an epitope which is specifically immunoreactive with an antibody included in the kit. Preferably, the kits
35 of the present invention further comprise a control antibody which does not react with the polypeptide of interest. In another specific embodiment, the kits of the present

5 invention contain a means for detecting the binding of an antibody to a polypeptide of interest (e.g., the antibody may be conjugated to a detectable substrate such as a fluorescent compound, an enzymatic substrate, a radioactive compound or a luminescent compound, or a second antibody which recognizes the first antibody may be conjugated to a detectable substrate).

10 In another specific embodiment of the present invention, the kit is a diagnostic kit for use in screening serum containing antibodies specific against proliferative and/or cancerous polynucleotides and polypeptides. Such a kit may include a control antibody that does not react with the polypeptide of interest. Such a kit may include a substantially isolated polypeptide antigen comprising an epitope which is specifically
15 immunoreactive with at least one anti-polypeptide antigen antibody. Further, such a kit includes means for detecting the binding of said antibody to the antigen (e.g., the antibody may be conjugated to a fluorescent compound such as fluorescein or rhodamine which can be detected by flow cytometry). In specific embodiments, the kit may include a recombinantly produced or chemically synthesized polypeptide
20 antigen. The polypeptide antigen of the kit may also be attached to a solid support.

In a more specific embodiment the detecting means of the above-described kit includes a solid support to which said polypeptide antigen is attached. Such a kit may also include a non-attached reporter-labeled anti-human antibody. In this embodiment, binding of the antibody to the polypeptide antigen can be detected by
25 binding of the said reporter-labeled antibody.

In an additional embodiment, the invention includes a diagnostic kit for use in screening serum containing antigens of the polypeptide of the invention. The diagnostic kit includes a substantially isolated antibody specifically immunoreactive with polypeptide or polynucleotide antigens, and means for detecting the binding of
30 the polynucleotide or polypeptide antigen to the antibody. In one embodiment, the antibody is attached to a solid support. In a specific embodiment, the antibody may be a monoclonal antibody. The detecting means of the kit may include a second, labeled monoclonal antibody. Alternatively, or in addition, the detecting means may include a labeled, competing antigen.

35 In one diagnostic configuration, test serum is reacted with a solid phase reagent having a surface-bound antigen obtained by the methods of the present

invention. After binding with specific antigen antibody to the reagent and removing unbound serum components by washing, the reagent is reacted with reporter-labeled anti-human antibody to bind reporter to the reagent in proportion to the amount of bound anti-antigen antibody on the solid support. The reagent is again washed to remove unbound labeled antibody, and the amount of reporter associated with the reagent is determined. Typically, the reporter is an enzyme which is detected by incubating the solid phase in the presence of a suitable fluorometric, luminescent or colorimetric substrate (Sigma, St. Louis, MO).

The solid surface reagent in the above assay is prepared by known techniques for attaching protein material to solid support material, such as polymeric beads, dip sticks, 96-well plate or filter material. These attachment methods generally include non-specific adsorption of the protein to the support or covalent attachment of the protein, typically through a free amine group, to a chemically reactive group on the solid support, such as an activated carboxyl, hydroxyl, or aldehyde group. Alternatively, streptavidin coated plates can be used in conjunction with biotinylated antigen(s).

Thus, the invention provides an assay system or kit for carrying out this diagnostic method. The kit generally includes a support with surface-bound recombinant antigens, and a reporter-labeled anti-human antibody for detecting surface-bound anti-antigen antibody.

Fusion Proteins

Any polypeptide of the present invention can be used to generate fusion proteins. For example, the polypeptide of the present invention, when fused to a second protein, can be used as an antigenic tag. Antibodies raised against the polypeptide of the present invention can be used to indirectly detect the second protein by binding to the polypeptide. Moreover, because certain proteins target cellular locations based on trafficking signals, the polypeptides of the present invention can be used as targeting molecules once fused to other proteins.

Examples of domains that can be fused to polypeptides of the present invention include not only heterologous signal sequences, but also other heterologous

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5 functional regions. The fusion does not necessarily need to be direct, but may occur through linker sequences.

Moreover, fusion proteins may also be engineered to improve characteristics of the polypeptide of the present invention. For instance, a region of additional amino acids, particularly charged amino acids, may be added to the N-terminus of the
 10 polypeptide to improve stability and persistence during purification from the host cell or subsequent handling and storage. Peptide moieties may be added to the polypeptide to facilitate purification. Such regions may be removed prior to final preparation of the polypeptide. Similarly, peptide cleavage sites can be introduced in-between such peptide moieties, which could additionally be subjected to protease activity to remove
 15 said peptide(s) from the protein of the present invention. The addition of peptide moieties, including peptide cleavage sites, to facilitate handling of polypeptides are familiar and routine techniques in the art.

Moreover, polypeptides of the present invention, including fragments, and specifically epitopes, can be combined with parts of the constant domain of immunoglobulins (IgA, IgE, IgG, IgM) or portions thereof (CH1, CH2, CH3, and any
 20 combination thereof, including both entire domains and portions thereof), resulting in chimeric polypeptides. These fusion proteins facilitate purification and show an increased half-life in vivo. One reported example describes chimeric proteins consisting of the first two domains of the human CD4-polypeptide and various
 25 domains of the constant regions of the heavy or light chains of mammalian immunoglobulins. (EP A 394,827; Traunecker et al., Nature 331:84-86 (1988).) Fusion proteins having disulfide-linked dimeric structures (due to the IgG) can also be more efficient in binding and neutralizing other molecules, than the monomeric secreted protein or protein fragment alone. (Fountoulakis et al., J. Biochem.
 30 270:3958-3964 (1995).)

Similarly, EP-A-O 464 533 (Canadian counterpart 2045869) discloses fusion proteins comprising various portions of the constant region of immunoglobulin molecules together with another human protein or part thereof. In many cases, the Fc part in a fusion protein is beneficial in therapy and diagnosis, and thus can result in,
 35 for example, improved pharmacokinetic properties. (EP-A 0232 262.) Alternatively, deleting the Fc part after the fusion protein has been expressed, detected, and purified,

5 would be desired. For example, the Fc portion may hinder therapy and diagnosis if the fusion protein is used as an antigen for immunizations. In drug discovery, for example, human proteins, such as hIL-5, have been fused with Fc portions for the purpose of high-throughput screening assays to identify antagonists of hIL-5. (Sec. D. Bennett et al., J. Molecular Recognition 8:52-58 (1995); K. Johanson et al., J. Biol. Chem... 270:9459-9471 (1995).)

Moreover, the polypeptides of the present invention can be fused to marker sequences (also referred to as "tags"). Due to the availability of antibodies specific to such "tags", purification of the fused polypeptide of the invention, and/or its identification is significantly facilitated since antibodies specific to the polypeptides
15 of the invention are not required. Such purification may be in the form of an affinity purification whereby an anti-tag antibody or another type of affinity matrix (e.g., anti-tag antibody attached to the matrix of a flow-thru column) that binds to the epitope tag is present. In preferred embodiments, the marker amino acid sequence is a hexa-histidine peptide, such as the tag provided in a pQE vector (QIAGEN, Inc., 9259 Eton
20 Avenue, Chatsworth, CA, 91311), among others, many of which are commercially available. As described in Gentz et al., Proc. Natl. Acad. Sci. USA 86:821-824 (1989), for instance, hexa-histidine provides for convenient purification of the fusion protein. Another peptide tag useful for purification, the "HA" tag, corresponds to an epitope derived from the influenza hemagglutinin protein. (Wilson et al., Cell 37:767
25 (1984)).

The skilled artisan would acknowledge the existence of other "tags" which could be readily substituted for the tags referred to supra for purification and/or identification of polypeptides of the present invention (Jones C., et al., J Chromatogr A. 707(1):3-22 (1995)). For example, the c-myc tag and the 8F9, 3C7, 6E10, G4m B7
30 and 9E10 antibodies thereto (Evan et al., Molecular and Cellular Biology 5:3610-3616 (1985)); the Herpes Simplex virus glycoprotein D (gD) tag and its antibody (Paborsky et al., Protein Engineering, 3(6):547-553 (1990), the Flag-peptide – i.e., the octapeptide sequence DYKDDDDK (SEQ ID NO:22), (Hopp et al., Biotech. 6:1204-1210 (1988); the KT3 epitope peptide (Martin et al., Science, 255:192-194 (1992)); a-
35 tubulin epitope peptide (Skinner et al., J. Biol. Chem..., 266:15136-15166, (1991)); the T7 gene 10 protein peptide tag (Lutz-Freyermuth et al., Proc. Natl. Sci. USA,

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5 87:6363-6397 (1990)), the FITC epitope (Zymed, Inc.), the GFP epitope (Zymed, Inc.), and the Rhodamine epitope (Zymed, Inc.).

The present invention also encompasses the attachment of up to nine codons encoding a repeating series of up to nine arginine amino acids to the coding region of a polynucleotide of the present invention. The invention also encompasses chemically
10 derivitizing a polypeptide of the present invention with a repeating series of up to nine arginine amino acids. Such a tag, when attached to a polypeptide, has recently been shown to serve as a universal pass, allowing compounds access to the interior of cells without additional derivitization or manipulation (Wender, P., et al., unpublished data).

15 Protein fusions involving polypeptides of the present invention, including fragments and/or variants thereof, can be used for the following, non-limiting examples, subcellular localization of proteins, determination of protein-protein interactions via immunoprecipitation, purification of proteins via affinity chromatography, functional and/or structural characterization of protein. The present
20 invention also encompasses the application of hapten specific antibodies for any of the uses referenced above for epitope fusion proteins. For example, the polypeptides of the present invention could be chemically derivatized to attach hapten molecules (e.g., DNP, (Zymed, Inc.)). Due to the availability of monoclonal antibodies specific to such haptens, the protein could be readily purified using immunoprecipitation, for
25 example.

Polypeptides of the present invention, including fragments and/or variants thereof, in addition to, antibodies directed against such polypeptides, fragments, and/or variants, may be fused to any of a number of known, and yet to be determined, toxins, such as ricin, saporin (Mashiba H, et al., Ann. N. Y. Acad. Sci. 1999;886:233-
30 5), or HC toxin (Tonukari NJ, et al., Plant Cell. 2000 Feb;12(2):237-248), for example. Such fusions could be used to deliver the toxins to desired tissues for which a ligand or a protein capable of binding to the polypeptides of the invention exists.

The invention encompasses the fusion of antibodies directed against polypeptides of the present invention, including variants and fragments thereof, to
35 said toxins for delivering the toxin to specific locations in a cell, to specific tissues, and/or to specific species. Such bifunctional antibodies are known in the art, though a

5 review describing additional advantageous fusions, including citations for methods of production, can be found in P.J. Hudson, Curr. Opp. In. Imm. 11:548-557, (1999); this publication, in addition to the references cited therein, are hereby incorporated by reference in their entirety herein. In this context, the term "toxin" may be expanded to include any heterologous protein, a small molecule, radionucleotides, cytotoxic drugs, liposomes, adhesion molecules, glycoproteins, ligands, cell or tissue-specific ligands, 10 enzymes, of bioactive agents, biological response modifiers, anti-fungal agents, hormones, steroids, vitamins, peptides, peptide analogs, anti-allergenic agents, anti-tubercular agents, anti-viral agents, antibiotics, anti-protozoan agents, chelates, radioactive particles, radioactive ions, X-ray contrast agents, monoclonal antibodies, polyclonal antibodies and genetic material. In view of the present disclosure, one skilled in the art could determine whether any particular "toxin" could be used in the compounds of the present invention. Examples of suitable "toxins" listed above are exemplary only and are not intended to limit the "toxins" that may be used in the present invention. 15

20 Thus, any of these above fusions can be engineered using the polynucleotides or the polypeptides of the present invention.

Vectors, Host Cells, and Protein Production

25 The present invention also relates to vectors containing the polynucleotide of the present invention, host cells, and the production of polypeptides by recombinant techniques. The vector may be, for example, a phage, plasmid, viral, or retroviral vector. Retroviral vectors may be replication competent or replication defective. In the latter case, viral propagation generally will occur only in complementing host cells.

30 The polynucleotides may be joined to a vector containing a selectable marker for propagation in a host. Generally, a plasmid vector is introduced in a precipitate, such as a calcium phosphate precipitate, or in a complex with a charged lipid. If the vector is a virus, it may be packaged in vitro using an appropriate packaging cell line and then transduced into host cells.

35 The polynucleotide insert should be operatively linked to an appropriate promoter, such as the phage lambda PL promoter, the E. coli lac, trp, phoA and tac

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5 promoters, the SV40 early and late promoters and promoters of retroviral LTRs, to name a few. Other suitable promoters will be known to the skilled artisan. The expression constructs will further contain sites for transcription initiation, termination, and, in the transcribed region, a ribosome binding site for translation. The coding portion of the transcripts expressed by the constructs will preferably include a translation initiating codon at the beginning and a termination codon (UAA, UGA or
10 UAG) appropriately positioned at the end of the polypeptide to be translated.

As indicated, the expression vectors will preferably include at least one selectable marker. Such markers include dihydrofolate reductase, G418 or neomycin resistance for eukaryotic cell culture and tetracycline, kanamycin or ampicillin
15 resistance genes for culturing in *E. coli* and other bacteria. Representative examples of appropriate hosts include, but are not limited to, bacterial cells, such as *E. coli*, *Streptomyces* and *Salmonella typhimurium* cells; fungal cells, such as yeast cells (e.g., *Saccharomyces cerevisiae* or *Pichia pastoris* (ATCC Accession No. 201178)); insect cells such as *Drosophila* S2 and *Spodoptera Sf9* cells; animal cells such as
20 CHO, COS, 293, and Bowes melanoma cells; and plant cells. Appropriate culture mediums and conditions for the above-described host cells are known in the art.

Among vectors preferred for use in bacteria include pQE70, pQE60 and pQE-9, available from QIAGEN, Inc.; pBluescript vectors, Phagescript vectors, pNH8A, pNH16a, pNH18A, pNH46A, available from Stratagene Cloning Systems, Inc.; and
25 ptrc99a, pKK223-3, pKK233-3, pDR540, pRIT5 available from Pharmacia Biotech, Inc. Among preferred eukaryotic vectors are pWLNEO, pSV2CAT, pOG44, pXT1 and pSG available from Stratagene; and pSVK3, pBPV, pMSG and pSVL available from Pharmacia. Preferred expression vectors for use in yeast systems include, but are not limited to pYES2, pYD1, pTEF1/Zeo, pYES2/GS, pPICZ, pGAPZ, pGAPZalph,
30 pPIC9, pPIC3.5, pHIL-D2, pHIL-S1, pPIC3.5K, pPIC9K, and PAO815 (all available from Invitrogen, Carlsbad, CA). Other suitable vectors will be readily apparent to the skilled artisan.

Introduction of the construct into the host cell can be effected by calcium phosphate transfection, DEAE-dextran mediated transfection, cationic lipid-mediated
35 transfection, electroporation, transduction, infection, or other methods. Such methods are described in many standard laboratory manuals, such as Davis et al., Basic

5 Methods In Molecular Biology (1986). It is specifically contemplated that the polypeptides of the present invention may in fact be expressed by a host cell lacking a recombinant vector.

 A polypeptide of this invention can be recovered and purified from recombinant cell cultures by well-known methods including ammonium sulfate or
10 ethanol precipitation, acid extraction, anion or cation exchange chromatography, phosphocellulose chromatography, hydrophobic interaction chromatography, affinity chromatography, hydroxylapatite chromatography and lectin chromatography. Most preferably, high performance liquid chromatography ("HPLC") is employed for purification.

15 Polypeptides of the present invention, and preferably the secreted form, can also be recovered from: products purified from natural sources, including bodily fluids, tissues and cells, whether directly isolated or cultured; products of chemical synthetic procedures; and products produced by recombinant techniques from a prokaryotic or eukaryotic host, including, for example, bacterial, yeast, higher plant,
20 insect, and mammalian cells. Depending upon the host employed in a recombinant production procedure, the polypeptides of the present invention may be glycosylated or may be non-glycosylated. In addition, polypeptides of the invention may also include an initial modified methionine residue, in some cases as a result of host-mediated processes. Thus, it is well known in the art that the N-terminal methionine
25 encoded by the translation initiation codon generally is removed with high efficiency from any protein after translation in all eukaryotic cells. While the N-terminal methionine on most proteins also is efficiently removed in most prokaryotes, for some proteins, this prokaryotic removal process is inefficient, depending on the nature of the amino acid to which the N-terminal methionine is covalently linked.

30 In one embodiment, the yeast *Pichia pastoris* is used to express the polypeptide of the present invention in a eukaryotic system. *Pichia pastoris* is a methylotrophic yeast which can metabolize methanol as its sole carbon source. A main step in the methanol metabolism pathway is the oxidation of methanol to formaldehyde using O₂. This reaction is catalyzed by the enzyme alcohol oxidase. In
35 order to metabolize methanol as its sole carbon source, *Pichia pastoris* must generate high levels of alcohol oxidase due, in part, to the relatively low affinity of alcohol

5 oxidase for O₂. Consequently, in a growth medium depending on methanol as a main carbon source, the promoter region of one of the two alcohol oxidase genes (AOX1) is highly active. In the presence of methanol, alcohol oxidase produced from the AOX1 gene comprises up to approximately 30% of the total soluble protein in *Pichia pastoris*. See, Ellis, S.B., et al., *Mol. Cell. Biol.* 5:1111-21 (1985); Koutz, P.J., et al.,
10 *Yeast* 5:167-77 (1989); Tschopp, J.F., et al., *Nucl. Acids Res.* 15:3859-76 (1987). Thus, a heterologous coding sequence, such as, for example, a polynucleotide of the present invention, under the transcriptional regulation of all or part of the AOX1 regulatory sequence is expressed at exceptionally high levels in *Pichia* yeast grown in the presence of methanol.

15 In one example, the plasmid vector pPIC9K is used to express DNA encoding a polypeptide of the invention, as set forth herein, in a *Pichea* yeast system essentially as described in "Pichia Protocols: Methods in Molecular Biology," D.R. Higgins and J. Cregg, eds. The Humana Press, Totowa, NJ, 1998. This expression vector allows expression and secretion of a protein of the invention by virtue of the strong AOX1
20 promoter linked to the *Pichia pastoris* alkaline phosphatase (PHO) secretory signal peptide (i.e., leader) located upstream of a multiple cloning site.

Many other yeast vectors could be used in place of pPIC9K, such as, pYES2, pYD1, pTEF1/Zeo, pYES2/GS, pPICZ, pGAPZ, pGAPZalpha, pPIC9, pPIC3.5, pHIL-D2, pHIL-S1, pPIC3.5K, and PAO815, as one skilled in the art would readily
25 appreciate, as long as the proposed expression construct provides appropriately located signals for transcription, translation, secretion (if desired), and the like, including an in-frame AUG, as required.

In another embodiment, high-level expression of a heterologous coding sequence, such as, for example, a polynucleotide of the present invention, may be
30 achieved by cloning the heterologous polynucleotide of the invention into an expression vector such as, for example, pGAPZ or pGAPZalpha, and growing the yeast culture in the absence of methanol.

In addition to encompassing host cells containing the vector constructs discussed herein, the invention also encompasses primary, secondary, and
35 immortalized host cells of vertebrate origin, particularly mammalian origin, that have been engineered to delete or replace endogenous genetic material (e.g., coding

5 sequence), and/or to include genetic material (e.g., heterologous polynucleotide sequences) that is operably associated with the polynucleotides of the invention, and which activates, alters, and/or amplifies endogenous polynucleotides. For example, techniques known in the art may be used to operably associate heterologous control regions (e.g., promoter and/or enhancer) and endogenous polynucleotide sequences
10 via homologous recombination, resulting in the formation of a new transcription unit (see, e.g., U.S. Patent No. 5,641,670, issued June 24, 1997; U.S. Patent No. 5,733,761, issued March 31, 1998; International Publication No. WO 96/29411, published September 26, 1996; International Publication No. WO 94/12650, published August 4, 1994; Koller et al., Proc. Natl. Acad. Sci. USA 86:8932-8935
15 (1989); and Zijlstra et al., Nature 342:435-438 (1989), the disclosures of each of which are incorporated by reference in their entireties).

In addition, polypeptides of the invention can be chemically synthesized using techniques known in the art (e.g., see Creighton, 1983, Proteins: Structures and Molecular Principles, W.H. Freeman & Co., N.Y., and Hunkapiller et al., Nature,
20 310:105-111 (1984)). For example, a polypeptide corresponding to a fragment of a polypeptide sequence of the invention can be synthesized by use of a peptide synthesizer. Furthermore, if desired, nonclassical amino acids or chemical amino acid analogs can be introduced as a substitution or addition into the polypeptide sequence. Non-classical amino acids include, but are not limited to, to the D-isomers of the
25 common amino acids, 2,4-diaminobutyric acid, α -amino isobutyric acid, 4-aminobutyric acid, Abu, 2-amino butyric acid, g-Abu, e-Ahx, 6-amino hexanoic acid, Aib, 2-amino isobutyric acid, 3-amino propionic acid, ornithine, norleucine, norvaline, hydroxyproline, sarcosine, citrulline, homocitrulline, cysteic acid, t-butylglycine, t-butylalanine, phenylglycine, cyclohexylalanine, b-alanine, fluoro-
30 amino acids, designer amino acids such as b-methyl amino acids, Ca-methyl amino acids, Na-methyl amino acids, and amino acid analogs in general. Furthermore, the amino acid can be D (dextrorotary) or L (levorotary).

The invention encompasses polypeptides which are differentially modified during or after translation, e.g., by glycosylation, acetylation, phosphorylation,
35 amidation, derivatization by known protecting/blocking groups, proteolytic cleavage, linkage to an antibody molecule or other cellular ligand, etc. Any of numerous

5 chemical modifications may be carried out by known techniques, including but not limited, to specific chemical cleavage by cyanogen bromide, trypsin, chymotrypsin, papain, V8 protease, NaBH₄; acetylation, formylation, oxidation, reduction; metabolic synthesis in the presence of tunicamycin; etc.

Additional post-translational modifications encompassed by the invention
10 include, for example, e.g., N-linked or O-linked carbohydrate chains, processing of N-terminal or C-terminal ends), attachment of chemical moieties to the amino acid backbone, chemical modifications of N-linked or O-linked carbohydrate chains, and addition or deletion of an N-terminal methionine residue as a result of prokaryotic host cell expression. The polypeptides may also be modified with a detectable label,
15 such as an enzymatic, fluorescent, isotopic or affinity label to allow for detection and isolation of the protein, the addition of epitope tagged peptide fragments (e.g., FLAG, HA, GST, thioredoxin, maltose binding protein, etc.), attachment of affinity tags such as biotin and/or streptavidin, the covalent attachment of chemical moieties to the amino acid backbone, N- or C-terminal processing of the polypeptides ends (e.g.,
20 proteolytic processing), deletion of the N-terminal methionine residue, etc.

Also provided by the invention are chemically modified derivatives of the polypeptides of the invention which may provide additional advantages such as increased solubility, stability and circulating time of the polypeptide, or decreased immunogenicity (see U.S. Patent NO: 4,179,337). The chemical moieties for
25 derivitization may be selected from water soluble polymers such as polyethylene glycol, ethylene glycol/propylene glycol copolymers, carboxymethylcellulose, dextran, polyvinyl alcohol and the like. The polypeptides may be modified at random positions within the molecule, or at predetermined positions within the molecule and may include one, two, three or more attached chemical moieties.

30 The invention further encompasses chemical derivitization of the polypeptides of the present invention, preferably where the chemical is a hydrophilic polymer residue. Exemplary hydrophilic polymers, including derivatives, may be those that include polymers in which the repeating units contain one or more hydroxy groups (polyhydroxy polymers), including, for example, poly(vinyl alcohol); polymers in
35 which the repeating units contain one or more amino groups (polyamine polymers), including, for example, peptides, polypeptides, proteins and lipoproteins, such as

5 albumin and natural lipoproteins; polymers in which the repeating units contain one or more carboxy groups (polycarboxy polymers), including, for example, carboxymethylcellulose, alginic acid and salts thereof, such as sodium and calcium alginate, glycosaminoglycans and salts thereof, including salts of hyaluronic acid, phosphorylated and sulfonated derivatives of carbohydrates, genetic material, such as
10 interleukin-2 and interferon, and phosphorothioate oligomers; and polymers in which the repeating units contain one or more saccharide moieties (polysaccharide polymers), including, for example, carbohydrates.

The molecular weight of the hydrophilic polymers may vary, and is generally about 50 to about 5,000,000, with polymers having a molecular weight of about 100
15 to about 50,000 being preferred. The polymers may be branched or unbranched. More preferred polymers have a molecular weight of about 150 to about 10,000, with molecular weights of 200 to about 8,000 being even more preferred.

For polyethylene glycol, the preferred molecular weight is between about 1 kDa and about 100 kDa (the term "about" indicating that in preparations of
20 polyethylene glycol, some molecules will weigh more, some less, than the stated molecular weight) for ease in handling and manufacturing. Other sizes may be used, depending on the desired therapeutic profile (e.g., the duration of sustained release desired, the effects, if any on biological activity, the ease in handling, the degree or lack of antigenicity and other known effects of the polyethylene glycol to a
25 therapeutic protein or analog).

Additional preferred polymers which may be used to derivatize polypeptides of the invention, include, for example, poly(ethylene glycol) (PEG), poly(vinylpyrrolidone), polyoxomers, polysorbate and poly(vinyl alcohol), with PEG
30 polymers being particularly preferred. Preferred among the PEG polymers are PEG polymers having a molecular weight of from about 100 to about 10,000. More preferably, the PEG polymers have a molecular weight of from about 200 to about 8,000, with PEG 2,000, PEG 5,000 and PEG 8,000, which have molecular weights of 2,000, 5,000 and 8,000, respectively, being even more preferred. Other suitable hydrophilic polymers, in addition to those exemplified above, will be readily apparent
35 to one skilled in the art based on the present disclosure. Generally, the polymers used

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5 may include polymers that can be attached to the polypeptides of the invention via alkylation or acylation reactions.

The polyethylene glycol molecules (or other chemical moieties) should be attached to the protein with consideration of effects on functional or antigenic domains of the protein. There are a number of attachment methods available to those skilled in the art, e.g., EP 0 401 384, herein incorporated by reference (coupling PEG to G-CSF), see also Malik et al., *Exp. Hematol.* 20:1028-1035 (1992) (reporting pegylation of GM-CSF using tresyl chloride). For example, polyethylene glycol may be covalently bound through amino acid residues via a reactive group, such as, a free amino or carboxyl group. Reactive groups are those to which an activated polyethylene glycol molecule may be bound. The amino acid residues having a free amino group may include lysine residues and the N-terminal amino acid residues; those having a free carboxyl group may include aspartic acid residues glutamic acid residues and the C-terminal amino acid residue. Sulfhydryl groups may also be used as a reactive group for attaching the polyethylene glycol molecules. Preferred for therapeutic purposes is attachment at an amino group, such as attachment at the N-terminus or lysine group.

One may specifically desire proteins chemically modified at the N-terminus. Using polyethylene glycol as an illustration of the present composition, one may select from a variety of polyethylene glycol molecules (by molecular weight, branching, etc.), the proportion of polyethylene glycol molecules to protein (polypeptide) molecules in the reaction mix, the type of pegylation reaction to be performed, and the method of obtaining the selected N-terminally pegylated protein. The method of obtaining the N-terminally pegylated preparation (i.e., separating this moiety from other monopegylated moieties if necessary) may be by purification of the N-terminally pegylated material from a population of pegylated protein molecules. Selective proteins chemically modified at the N-terminus modification may be accomplished by reductive alkylation which exploits differential reactivity of different types of primary amino groups (lysine versus the N-terminus) available for derivatization in a particular protein. Under the appropriate reaction conditions, substantially selective derivatization of the protein at the N-terminus with a carbonyl group containing polymer is achieved.

5 As with the various polymers exemplified above, it is contemplated that the polymeric residues may contain functional groups in addition, for example, to those typically involved in linking the polymeric residues to the polypeptides of the present invention. Such functionalities include, for example, carboxyl, amine, hydroxy and thiol groups. These functional groups on the polymeric residues can be further
10 reacted, if desired, with materials that are generally reactive with such functional groups and which can assist in targeting specific tissues in the body including, for example, diseased tissue. Exemplary materials which can be reacted with the additional functional groups include, for example, proteins, including antibodies, carbohydrates, peptides, glycopeptides, glycolipids, lectins, and nucleosides.

15 In addition to residues of hydrophilic polymers, the chemical used to derivatize the polypeptides of the present invention can be a saccharide residue. Exemplary saccharides which can be derived include, for example, monosaccharides or sugar alcohols, such as erythrose, threose, ribose, arabinose, xylose, lyxose, fructose, sorbitol, mannitol and sedoheptulose, with preferred monosaccharides being
20 fructose, mannose, xylose, arabinose, mannitol and sorbitol; and disaccharides, such as lactose, sucrose, maltose and cellobiose. Other saccharides include, for example, inositol and ganglioside head groups. Other suitable saccharides, in addition to those exemplified above, will be readily apparent to one skilled in the art based on the present disclosure. Generally, saccharides which may be used for derivitization
25 include saccharides that can be attached to the polypeptides of the invention via alkylation or acylation reactions.

Moreover, the invention also encompasses derivitization of the polypeptides of the present invention, for example, with lipids (including cationic, anionic, polymerized, charged, synthetic, saturated, unsaturated, and any combination of the
30 above, etc.). stabilizing agents.

The invention encompasses derivitization of the polypeptides of the present invention, for example, with compounds that may serve a stabilizing function (e.g., to increase the polypeptides half-life in solution, to make the polypeptides more water soluble, to increase the polypeptides hydrophilic or hydrophobic character, etc.).
35 Polymers useful as stabilizing materials may be of natural, semi-synthetic (modified natural) or synthetic origin. Exemplary natural polymers include naturally occurring

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5 polysaccharides, such as, for example, arabinans, fructans, fucans, galactans, galacturonans, glucans, mannans, xylans (such as, for example, inulin), levan, fucoidan, carrageenan, galatocarlose, pectic acid, pectins, including amylose, pullulan, glycogen, amylopectin, cellulose, dextran, dextrin, dextrose, glucose, polyglucose, polydextrose, pustulan, chitin, agarose, keratin, chondroitin, dermatan,
 10 hyaluronic acid, alginic acid, xanthin gum, starch and various other natural homopolymer or heteropolymers, such as those containing one or more of the following aldoses, ketoses, acids or amines: erythrose, threose, ribose, arabinose, xylose, lyxose, allose, altrose, glucose, dextrose, mannose, gulose, idose, galactose, talose, erythrulose, ribulose, xylulose, psicose, fructose, sorbose, tagatose, mannitol, sorbitol, lactose, sucrose, trehalose, maltose, cellobiose, glycine, serine, threonine, cysteine, tyrosine, asparagine, glutamine, aspartic acid, glutamic acid, lysine, arginine, histidine, glucuronic acid, gluconic acid, glucaric acid, galacturonic acid, mannuronic acid, glucosamine, galactosamine, and neuraminic acid, and naturally occurring derivatives thereof Accordingly, suitable polymers include, for example,
 15 proteins, such as albumin, polyalginates, and polylactide-coglycolide polymers. Exemplary semi-synthetic polymers include carboxymethylcellulose, hydroxymethylcellulose, hydroxypropylmethylcellulose, methylcellulose, and methoxycellulose. Exemplary synthetic polymers include polyphosphazenes, hydroxyapatites, fluoroapatite polymers, polyethylenes (such as, for example, polyethylene glycol (including for example, the class of compounds referred to as Pluronic[®] RTM., commercially available from BASF, Parsippany, N.J.), polyoxyethylene, and polyethylene terephthalate), polypropylenes (such as, for example, polypropylene glycol), polyurethanes (such as, for example, polyvinyl alcohol (PVA), polyvinyl chloride and polyvinylpyrrolidone), polyamides including
 25 nylon, polystyrene, polylactic acids, fluorinated hydrocarbon polymers, fluorinated carbon polymers (such as, for example, polytetrafluoroethylene), acrylate, methacrylate, and polymethylmethacrylate, and derivatives thereof. Methods for the preparation of derivatized polypeptides of the invention which employ polymers as stabilizing compounds will be readily apparent to one skilled in the art, in view of the present disclosure, when coupled with information known in the art, such as that
 30

5 described and referred to in Unger, U.S. Pat. No. 5,205,290, the disclosure of which is hereby incorporated by reference herein in its entirety.

Moreover, the invention encompasses additional modifications of the polypeptides of the present invention. Such additional modifications are known in the art, and are specifically provided, in addition to methods of derivitization, etc., in US
10 Patent No. 6,028,066, which is hereby incorporated in its entirety herein.

The polypeptides of the invention may be in monomers or multimers (i.e., dimers, trimers, tetramers and higher multimers). Accordingly, the present invention relates to monomers and multimers of the polypeptides of the invention, their preparation, and compositions (preferably, Therapeutics) containing them. In specific
15 embodiments, the polypeptides of the invention are monomers, dimers, trimers or tetramers. In additional embodiments, the multimers of the invention are at least dimers, at least trimers, or at least tetramers.

Multimers encompassed by the invention may be homomers or heteromers. As used herein, the term homomer, refers to a multimer containing only polypeptides
20 corresponding to the amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, or encoded by the cDNA contained in a deposited clone (including fragments, variants, splice variants, and fusion proteins, corresponding to these polypeptides as described herein). These homomers may contain polypeptides having identical or different amino acid sequences. In a specific embodiment, a homomer of the invention is a
25 multimer containing only polypeptides having an identical amino acid sequence. In another specific embodiment, a homomer of the invention is a multimer containing polypeptides having different amino acid sequences. In specific embodiments, the multimer of the invention is a homodimer (e.g., containing polypeptides having identical or different amino acid sequences) or a homotrimer (e.g., containing
30 polypeptides having identical and/or different amino acid sequences). In additional embodiments, the homomeric multimer of the invention is at least a homodimer, at least a homotrimer, or at least a homotetramer.

As used herein, the term heteromer refers to a multimer containing one or more heterologous polypeptides (i.e., polypeptides of different proteins) in addition to
35 the polypeptides of the invention. In a specific embodiment, the multimer of the invention is a heterodimer, a heterotrimer, or a heterotetramer. In additional

5 embodiments, the heteromeric multimer of the invention is at least a heterodimer, at least a heterotrimer, or at least a heterotetramer.

 Multimers of the invention may be the result of hydrophobic, hydrophilic, ionic and/or covalent associations and/or may be indirectly linked, by for example, liposome formation. Thus, in one embodiment, multimers of the invention, such as, 10 for example, homodimers or homotrimers, are formed when polypeptides of the invention contact one another in solution. In another embodiment, heteromultimers of the invention, such as, for example, heterotrimers or heterotetramers, are formed when polypeptides of the invention contact antibodies to the polypeptides of the invention (including antibodies to the heterologous polypeptide sequence in a fusion 15 protein of the invention) in solution. In other embodiments, multimers of the invention are formed by covalent associations with and/or between the polypeptides of the invention. Such covalent associations may involve one or more amino acid residues contained in the polypeptide sequence (e.g., that recited in the sequence listing, or contained in the polypeptide encoded by a deposited clone). In one instance, 20 the covalent associations are cross-linking between cysteine residues located within the polypeptide sequences which interact in the native (i.e., naturally occurring) polypeptide. In another instance, the covalent associations are the consequence of chemical or recombinant manipulation. Alternatively, such covalent associations may involve one or more amino acid residues contained in the heterologous polypeptide 25 sequence in a fusion protein of the invention.

 In one example, covalent associations are between the heterologous sequence contained in a fusion protein of the invention (see, e.g., US Patent Number 5,478,925). In a specific example, the covalent associations are between the heterologous sequence contained in an Fc fusion protein of the invention (as described 30 herein). In another specific example, covalent associations of fusion proteins of the invention are between heterologous polypeptide sequence from another protein that is capable of forming covalently associated multimers, such as for example, osteoprotegerin (see, e.g., International Publication NO: WO 98/49305, the contents of which are herein incorporated by reference in its entirety). In another embodiment, 35 two or more polypeptides of the invention are joined through peptide linkers. Examples include those peptide linkers described in U.S. Pat. No. 5,073,627 (hereby

5 incorporated by reference). Proteins comprising multiple polypeptides of the invention separated by peptide linkers may be produced using conventional recombinant DNA technology.

Another method for preparing multimer polypeptides of the invention involves use of polypeptides of the invention fused to a leucine zipper or isoleucine zipper
10 polypeptide sequence. Leucine zipper and isoleucine zipper domains are polypeptides that promote multimerization of the proteins in which they are found. Leucine zippers were originally identified in several DNA-binding proteins (Landschulz et al., Science 240:1759, (1988)), and have since been found in a variety of different proteins. Among the known leucine zippers are naturally occurring peptides and derivatives
15 thereof that dimerize or trimerize. Examples of leucine zipper domains suitable for producing soluble multimeric proteins of the invention are those described in PCT application WO 94/10308, hereby incorporated by reference. Recombinant fusion proteins comprising a polypeptide of the invention fused to a polypeptide sequence that dimerizes or trimerizes in solution are expressed in suitable host cells, and the
20 resulting soluble multimeric fusion protein is recovered from the culture supernatant using techniques known in the art.

Trimeric polypeptides of the invention may offer the advantage of enhanced biological activity. Preferred leucine zipper moieties and isoleucine moieties are those that preferentially form trimers. One example is a leucine zipper derived from lung
25 surfactant protein D (SPD), as described in Hoppe et al. (FEBS Letters 344:191, (1994)) and in U.S. patent application Ser. No. 08/446,922, hereby incorporated by reference. Other peptides derived from naturally occurring trimeric proteins may be employed in preparing trimeric polypeptides of the invention.

In another example, proteins of the invention are associated by interactions
30 between Flag® polypeptide sequence contained in fusion proteins of the invention containing Flag® polypeptide sequence. In a further embodiment, associations proteins of the invention are associated by interactions between heterologous polypeptide sequence contained in Flag® fusion proteins of the invention and anti-Flag® antibody.

35 The multimers of the invention may be generated using chemical techniques known in the art. For example, polypeptides desired to be contained in the multimers

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5 of the invention may be chemically cross-linked using linker molecules and linker molecule length optimization techniques known in the art (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). Additionally, multimers of the invention may be generated using techniques known in the art to form one or more inter-molecule cross-links between the cysteine residues
10 located within the sequence of the polypeptides desired to be contained in the multimer (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). Further, polypeptides of the invention may be routinely modified by the addition of cysteine or biotin to the C terminus or N-terminus of the polypeptide and techniques known in the art may be applied to generate multimers
15 containing one or more of these modified polypeptides (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). Additionally, techniques known in the art may be applied to generate liposomes containing the polypeptide components desired to be contained in the multimer of the invention (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its
20 entirety).

Alternatively, multimers of the invention may be generated using genetic engineering techniques known in the art. In one embodiment, polypeptides contained in multimers of the invention are produced recombinantly using fusion protein technology described herein or otherwise known in the art (see, e.g., US Patent
25 Number 5,478,925, which is herein incorporated by reference in its entirety). In a specific embodiment, polynucleotides coding for a homodimer of the invention are generated by ligating a polynucleotide sequence encoding a polypeptide of the invention to a sequence encoding a linker polypeptide and then further to a synthetic polynucleotide encoding the translated product of the polypeptide in the reverse
30 orientation from the original C-terminus to the N-terminus (lacking the leader sequence) (see, e.g., US Patent Number 5,478,925, which is herein incorporated by reference in its entirety). In another embodiment, recombinant techniques described herein or otherwise known in the art are applied to generate recombinant polypeptides of the invention which contain a transmembrane domain (or hydrophobic or signal
35 peptide) and which can be incorporated by membrane reconstitution techniques into liposomes (see, e.g., US Patent Number 5,478,925, which is herein incorporated by

5 reference in its entirety).

In addition, the polynucleotide insert of the present invention could be operatively linked to "artificial" or chimeric promoters and transcription factors. Specifically, the artificial promoter could comprise, or alternatively consist, of any combination of cis-acting DNA sequence elements that are recognized by trans-acting
10 transcription factors. Preferably, the cis acting DNA sequence elements and trans-acting transcription factors are operable in mammals. Further, the trans-acting transcription factors of such "artificial" promoters could also be "artificial" or chimeric in design themselves and could act as activators or repressors to said "artificial" promoter.

15

Uses of the Polynucleotides

Each of the polynucleotides identified herein can be used in numerous ways as reagents. The following description should be considered exemplary and utilizes
20 known techniques.

The polynucleotides of the present invention are useful for chromosome identification. There exists an ongoing need to identify new chromosome markers, since few chromosome marking reagents, based on actual sequence data (repeat polymorphisms), are presently available. Each polynucleotide of the present invention
25 can be used as a chromosome marker.

Briefly, sequences can be mapped to chromosomes by preparing PCR primers (preferably 15-25 bp) from the sequences shown in SEQ ID NO:1, or SEQ ID NO:23. Primers can be selected using computer analysis so that primers do not span more than one predicted exon in the genomic DNA. These primers are then used for PCR
30 screening of somatic cell hybrids containing individual human chromosomes. Only those hybrids containing the human gene corresponding to the SEQ ID NO:1, or SEQ ID NO:23, will yield an amplified fragment.

Similarly, somatic hybrids provide a rapid method of PCR mapping the polynucleotides to particular chromosomes. Three or more clones can be assigned per
35 day using a single thermal cycler. Moreover, sublocalization of the polynucleotides can be achieved with panels of specific chromosome fragments. Other gene mapping

5 strategies that can be used include in situ hybridization, prescreening with labeled flow-sorted chromosomes, and preselection by hybridization to construct chromosome specific-cDNA libraries.

Precise chromosomal location of the polynucleotides can also be achieved using fluorescence in situ hybridization (FISH) of a metaphase chromosomal spread.
10 This technique uses polynucleotides as short as 500 or 600 bases; however, polynucleotides 2,000-4,000 bp are preferred. For a review of this technique, see Verma et al., "Human Chromosomes: a Manual of Basic Techniques," Pergamon Press, New York (1988).

For chromosome mapping, the polynucleotides can be used individually (to
15 mark a single chromosome or a single site on that chromosome) or in panels (for marking multiple sites and/or multiple chromosomes). Preferred polynucleotides correspond to the noncoding regions of the cDNAs because the coding sequences are more likely conserved within gene families, thus increasing the chance of cross hybridization during chromosomal mapping.

20 Once a polynucleotide has been mapped to a precise chromosomal location, the physical position of the polynucleotide can be used in linkage analysis. Linkage analysis establishes coinheritance between a chromosomal location and presentation of a particular disease. Disease mapping data are known in the art. Assuming 1 megabase mapping resolution and one gene per 20 kb, a cDNA precisely localized to
25 a chromosomal region associated with the disease could be one of 50-500 potential causative genes.

Thus, once coinheritance is established, differences in the polynucleotide and the corresponding gene between affected and unaffected organisms can be examined. First, visible structural alterations in the chromosomes, such as deletions or
30 translocations, are examined in chromosome spreads or by PCR. If no structural alterations exist, the presence of point mutations are ascertained. Mutations observed in some or all affected organisms, but not in normal organisms, indicates that the mutation may cause the disease. However, complete sequencing of the polypeptide and the corresponding gene from several normal organisms is required to distinguish
35 the mutation from a polymorphism. If a new polymorphism is identified, this polymorphic polypeptide can be used for further linkage analysis.

5 Furthermore, increased or decreased expression of the gene in affected organisms as compared to unaffected organisms can be assessed using polynucleotides of the present invention. Any of these alterations (altered expression, chromosomal rearrangement, or mutation) can be used as a diagnostic or prognostic marker.

10 Thus, the invention also provides a diagnostic method useful during diagnosis of a disorder, involving measuring the expression level of polynucleotides of the present invention in cells or body fluid from an organism and comparing the measured gene expression level with a standard level of polynucleotide expression level, whereby an increase or decrease in the gene expression level compared to the
15 standard is indicative of a disorder.

By "measuring the expression level of a polynucleotide of the present invention" is intended qualitatively or quantitatively measuring or estimating the level of the polypeptide of the present invention or the level of the mRNA encoding the polypeptide in a first biological sample either directly (e.g., by determining or
20 estimating absolute protein level or mRNA level) or relatively (e.g., by comparing to the polypeptide level or mRNA level in a second biological sample). Preferably, the polypeptide level or mRNA level in the first biological sample is measured or estimated and compared to a standard polypeptide level or mRNA level, the standard being taken from a second biological sample obtained from an individual not having
25 the disorder or being determined by averaging levels from a population of organisms not having a disorder. As will be appreciated in the art, once a standard polypeptide level or mRNA level is known, it can be used repeatedly as a standard for comparison.

By "biological sample" is intended any biological sample obtained from an
30 organism, body fluids, cell line, tissue culture, or other source which contains the polypeptide of the present invention or mRNA. As indicated, biological samples include body fluids (such as the following non-limiting examples, sputum, amniotic fluid, urine, saliva, breast milk, secretions, interstitial fluid, blood, serum, spinal fluid, etc.) which contain the polypeptide of the present invention, and other tissue sources
35 found to express the polypeptide of the present invention. Methods for obtaining

5 tissue biopsies and body fluids from organisms are well known in the art. Where the biological sample is to include mRNA, a tissue biopsy is the preferred source.

The method(s) provided above may Preferably be applied in a diagnostic method and/or kits in which polynucleotides and/or polypeptides are attached to a solid support. In one exemplary method, the support may be a “gene chip” or a
10 “biological chip” as described in US Patents 5,837,832, 5,874,219, and 5,856,174. Further, such a gene chip with polynucleotides of the present invention attached may be used to identify polymorphisms between the polynucleotide sequences, with polynucleotides isolated from a test subject. The knowledge of such polymorphisms (i.e. their location, as well as, their existence) would be beneficial in identifying
15 disease loci for many disorders, including proliferative diseases and conditions. Such a method is described in US Patents 5,858,659 and 5,856,104. The US Patents referenced supra are hereby incorporated by reference in their entirety herein.

The present invention encompasses polynucleotides of the present invention that are chemically synthesized, or reproduced as peptide nucleic acids (PNA), or
20 according to other methods known in the art. The use of PNAs would serve as the preferred form if the polynucleotides are incorporated onto a solid support, or gene chip. For the purposes of the present invention, a peptide nucleic acid (PNA) is a polyamide type of DNA analog and the monomeric units for adenine, guanine, thymine and cytosine are available commercially (Perceptive Biosystems). Certain
25 components of DNA, such as phosphorus, phosphorus oxides, or deoxyribose derivatives, are not present in PNAs. As disclosed by P. E. Nielsen, M. Egholm, R. H. Berg and O. Buchardt, Science 254, 1497 (1991); and M. Egholm, O. Buchardt, L.Christensen, C. Behrens, S. M. Freier, D. A. Driver, R. H. Berg, S. K. Kim, B. Norden, and P. E. Nielsen, Nature 365, 666 (1993), PNAs bind specifically and
30 tightly to complementary DNA strands and are not degraded by nucleases. In fact, PNA binds more strongly to DNA than DNA itself does. This is probably because there is no electrostatic repulsion between the two strands, and also the polyamide backbone is more flexible. Because of this, PNA/DNA duplexes bind under a wider range of stringency conditions than DNA/DNA duplexes, making it easier to perform
35 multiplex hybridization. Smaller probes can be used than with DNA due to the stronger binding characteristics of PNA:DNA hybrids. In addition, it is more likely

In addition to the foregoing, a polynucleotide can be used to control gene expression through triple helix formation or antisense DNA or RNA. Antisense techniques are discussed, for example, in Okano, J. Neurochem. 56: 560 (1991); "Oligodeoxynucleotides as Antisense Inhibitors of Gene Expression, CRC Press, Boca Raton, FL (1988). Triple helix formation is discussed in, for instance Lee et al., Nucleic Acids Research 6: 3073 (1979); Cooney et al., Science 241: 456 (1988); and Dervan et al., Science 251: 1360 (1991). Both methods rely on binding of the polynucleotide to a complementary DNA or RNA. For these techniques, preferred polynucleotides are usually oligonucleotides 20 to 40 bases in length and complementary to either the region of the gene involved in transcription (triple helix - see Lee et al., Nucl. Acids Res. 6:3073 (1979); Cooney et al., Science 241:456 (1988); and Dervan et al., Science 251:1360 (1991)) or to the mRNA itself (antisense - Okano, J. Neurochem. 56:560 (1991); Oligodeoxy-nucleotides as Antisense Inhibitors of Gene Expression, CRC Press, Boca Raton, FL (1988).) Triple helix formation optimally results in a shut-off of RNA transcription from DNA, while antisense RNA hybridization blocks translation of an mRNA molecule into polypeptide. Both techniques are effective in model systems, and the information disclosed herein can be used to design antisense or triple helix polynucleotides in an effort to treat or prevent disease.

35 Polynucleotides of the present invention are also useful in gene therapy. One goal of gene therapy is to insert a normal gene into an organism having a defective

5 gene, in an effort to correct the genetic defect. The polynucleotides disclosed in the present invention offer a means of targeting such genetic defects in a highly accurate manner. Another goal is to insert a new gene that was not present in the host genome, thereby producing a new trait in the host cell. In one example, polynucleotide sequences of the present invention may be used to construct chimeric RNA/DNA
10 oligonucleotides corresponding to said sequences, specifically designed to induce host cell mismatch repair mechanisms in an organism upon systemic injection, for example (Bartlett, R.J., et al., Nat. Biotech, 18:615-622 (2000), which is hereby incorporated by reference herein in its entirety). Such RNA/DNA oligonucleotides could be designed to correct genetic defects in certain host strains, and/or to introduce desired
15 phenotypes in the host (e.g., introduction of a specific polymorphism within an endogenous gene corresponding to a polynucleotide of the present invention that may ameliorate and/or prevent a disease symptom and/or disorder, etc.). Alternatively, the polynucleotide sequence of the present invention may be used to construct duplex oligonucleotides corresponding to said sequence, specifically designed to correct
20 genetic defects in certain host strains, and/or to introduce desired phenotypes into the host (e.g., introduction of a specific polymorphism within an endogenous gene corresponding to a polynucleotide of the present invention that may ameliorate and/or prevent a disease symptom and/or disorder, etc). Such methods of using duplex oligonucleotides are known in the art and are encompassed by the present invention
25 (see EP1007712, which is hereby incorporated by reference herein in its entirety).

The polynucleotides are also useful for identifying organisms from minute biological samples. The United States military, for example, is considering the use of restriction fragment length polymorphism (RFLP) for identification of its personnel. In this technique, an individual's genomic DNA is digested with one or more
30 restriction enzymes, and probed on a Southern blot to yield unique bands for identifying personnel. This method does not suffer from the current limitations of "Dog Tags" which can be lost, switched, or stolen, making positive identification difficult. The polynucleotides of the present invention can be used as additional DNA markers for RFLP.

35 The polynucleotides of the present invention can also be used as an alternative to RFLP, by determining the actual base-by-base DNA sequence of selected portions

5 of an organisms genome. These sequences can be used to prepare PCR primers for amplifying and isolating such selected DNA, which can then be sequenced. Using this technique, organisms can be identified because each organism will have a unique set of DNA sequences. Once an unique ID database is established for an organism, positive identification of that organism, living or dead, can be made from extremely
10 small tissue samples. Similarly, polynucleotides of the present invention can be used as polymorphic markers, in addition to, the identification of transformed or non-transformed cells and/or tissues.

There is also a need for reagents capable of identifying the source of a particular tissue. Such need arises, for example, when presented with tissue of
15 unknown origin. Appropriate reagents can comprise, for example, DNA probes or primers specific to particular tissue prepared from the sequences of the present invention. Panels of such reagents can identify tissue by species and/or by organ type. In a similar fashion, these reagents can be used to screen tissue cultures for contamination. Moreover, as mentioned above, such reagents can be used to screen
20 and/or identify transformed and non-transformed cells and/or tissues.

In the very least, the polynucleotides of the present invention can be used as molecular weight markers on Southern gels, as diagnostic probes for the presence of a specific mRNA in a particular cell type, as a probe to "subtract-out" known sequences in the process of discovering novel polynucleotides, for selecting and making
25 oligomers for attachment to a "gene chip" or other support, to raise anti-DNA antibodies using DNA immunization techniques, and as an antigen to elicit an immune response.

Uses of the Polypeptides

30 Each of the polypeptides identified herein can be used in numerous ways. The following description should be considered exemplary and utilizes known techniques.

A polypeptide of the present invention can be used to assay protein levels in a biological sample using antibody-based techniques. For example, protein expression in tissues can be studied with classical immunohistological methods. (Jalkanen, M., et
35 al., J. Cell. Biol. 101:976-985 (1985); Jalkanen, M., et al., J. Cell . Biol. 105:3087-3096 (1987).) Other antibody-based methods useful for detecting protein gene

5 expression include immunoassays, such as the enzyme linked immunosorbent assay (ELISA) and the radioimmunoassay (RIA). Suitable antibody assay labels are known in the art and include enzyme labels, such as, glucose oxidase, and radioisotopes, such as iodine (125I, 121I), carbon (14C), sulfur (35S), tritium (3H), indium (112In), and technetium (99mTc), and fluorescent labels, such as fluorescein and rhodamine, and
10 biotin.

In addition to assaying protein levels in a biological sample, proteins can also be detected in vivo by imaging. Antibody labels or markers for in vivo imaging of protein include those detectable by X-radiography, NMR or ESR. For X-radiography, suitable labels include radioisotopes such as barium or cesium, which emit detectable
15 radiation but are not overtly harmful to the subject. Suitable markers for NMR and ESR include those with a detectable characteristic spin, such as deuterium, which may be incorporated into the antibody by labeling of nutrients for the relevant hybridoma.

A protein-specific antibody or antibody fragment which has been labeled with an appropriate detectable imaging moiety, such as a radioisotope (for example, 131I, 112In, 99mTc), a radio-opaque substance, or a material detectable by nuclear
20 magnetic resonance, is introduced (for example, parenterally, subcutaneously, or intraperitoneally) into the mammal. It will be understood in the art that the size of the subject and the imaging system used will determine the quantity of imaging moiety needed to produce diagnostic images. In the case of a radioisotope moiety, for a
25 human subject, the quantity of radioactivity injected will normally range from about 5 to 20 millicuries of 99mTc. The labeled antibody or antibody fragment will then preferentially accumulate at the location of cells which contain the specific protein. In vivo tumor imaging is described in S.W. Burchiel et al., "Immunopharmacokinetics of Radiolabeled Antibodies and Their Fragments." (Chapter 13 in Tumor Imaging: The
30 Radiochemical Detection of Cancer, S.W. Burchiel and B. A. Rhodes, eds., Masson Publishing Inc. (1982).)

Thus, the invention provides a diagnostic method of a disorder, which involves (a) assaying the expression of a polypeptide of the present invention in cells or body fluid of an individual; (b) comparing the level of gene expression with a
35 standard gene expression level, whereby an increase or decrease in the assayed polypeptide gene expression level compared to the standard expression level is

5 indicative of a disorder. With respect to cancer, the presence of a relatively high amount of transcript in biopsied tissue from an individual may indicate a predisposition for the development of the disease, or may provide a means for detecting the disease prior to the appearance of actual clinical symptoms. A more definitive diagnosis of this type may allow health professionals to employ
10 preventative measures or aggressive treatment earlier thereby preventing the development or further progression of the cancer.

Moreover, polypeptides of the present invention can be used to treat, prevent, and/or diagnose disease. For example, patients can be administered a polypeptide of the present invention in an effort to replace absent or decreased levels of the
15 polypeptide (e.g., insulin), to supplement absent or decreased levels of a different polypeptide (e.g., hemoglobin S for hemoglobin B, SOD, catalase, DNA repair proteins), to inhibit the activity of a polypeptide (e.g., an oncogene or tumor suppressor), to activate the activity of a polypeptide (e.g., by binding to a receptor), to reduce the activity of a membrane bound receptor by competing with it for free ligand
20 (e.g., soluble TNF receptors used in reducing inflammation), or to bring about a desired response (e.g., blood vessel growth inhibition, enhancement of the immune response to proliferative cells or tissues).

Similarly, antibodies directed to a polypeptide of the present invention can also be used to treat, prevent, and/or diagnose disease. For example, administration of
25 an antibody directed to a polypeptide of the present invention can bind and reduce overproduction of the polypeptide. Similarly, administration of an antibody can activate the polypeptide, such as by binding to a polypeptide bound to a membrane (receptor).

At the very least, the polypeptides of the present invention can be used as
30 molecular weight markers on SDS-PAGE gels or on molecular sieve gel filtration columns using methods well known to those of skill in the art. Polypeptides can also be used to raise antibodies, which in turn are used to measure protein expression from a recombinant cell, as a way of assessing transformation of the host cell. Moreover, the polypeptides of the present invention can be used to test the following biological
35 activities.

5 Gene Therapy Methods

Another aspect of the present invention is to gene therapy methods for treating or preventing disorders, diseases and conditions. The gene therapy methods relate to the introduction of nucleic acid (DNA, RNA and antisense DNA or RNA) sequences into an animal to achieve expression of a polypeptide of the present invention. This method requires a polynucleotide which codes for a polypeptide of the invention that operatively linked to a promoter and any other genetic elements necessary for the expression of the polypeptide by the target tissue. Such gene therapy and delivery techniques are known in the art, see, for example, WO90/11092, which is herein incorporated by reference.

Thus, for example, cells from a patient may be engineered with a polynucleotide (DNA or RNA) comprising a promoter operably linked to a polynucleotide of the invention ex vivo, with the engineered cells then being provided to a patient to be treated with the polypeptide. Such methods are well-known in the art. For example, see Belldegrün et al., J. Natl. Cancer Inst., 85:207-216 (1993); Ferrantini et al., Cancer Research, 53:107-1112 (1993); Ferrantini et al., J. Immunology 153: 4604-4615 (1994); Kaido, T., et al., Int. J. Cancer 60: 221-229 (1995); Ogura et al., Cancer Research 50: 5102-5106 (1990); Santodonato, et al., Human Gene Therapy 7:1-10 (1996); Santodonato, et al., Gene Therapy 4:1246-1255 (1997); and Zhang, et al., Cancer Gene Therapy 3: 31-38 (1996)), which are herein incorporated by reference. In one embodiment, the cells which are engineered are arterial cells. The arterial cells may be reintroduced into the patient through direct injection to the artery, the tissues surrounding the artery, or through catheter injection.

As discussed in more detail below, the polynucleotide constructs can be delivered by any method that delivers injectable materials to the cells of an animal, such as, injection into the interstitial space of tissues (heart, muscle, skin, lung, liver, and the like). The polynucleotide constructs may be delivered in a pharmaceutically acceptable liquid or aqueous carrier.

In one embodiment, the polynucleotide of the invention is delivered as a naked polynucleotide. The term "naked" polynucleotide, DNA or RNA refers to sequences that are free from any delivery vehicle that acts to assist, promote or facilitate entry into the cell, including viral sequences, viral particles, liposome formulations,

5 lipofectin or precipitating agents and the like. However, the polynucleotides of the invention can also be delivered in liposome formulations and lipofectin formulations and the like can be prepared by methods well known to those skilled in the art. Such methods are described, for example, in U.S. Patent Nos. 5,593,972, 5,589,466, and 5,580,859, which are herein incorporated by reference.

10 The polynucleotide vector constructs of the invention used in the gene therapy method are preferably constructs that will not integrate into the host genome nor will they contain sequences that allow for replication. Appropriate vectors include pWLNEO, pSV2CAT, pOG44, pXT1 and pSG available from Stratagene; pSVK3, pBPV, pMSG and pSVL available from Pharmacia; and pEF1/V5, pcDNA3.1, and
15 pRc/CMV2 available from Invitrogen. Other suitable vectors will be readily apparent to the skilled artisan.

Any strong promoter known to those skilled in the art can be used for driving the expression of polynucleotide sequence of the invention. Suitable promoters include adenoviral promoters, such as the adenoviral major late promoter; or
20 heterologous promoters, such as the cytomegalovirus (CMV) promoter; the respiratory syncytial virus (RSV) promoter; inducible promoters, such as the MMT promoter, the metallothionein promoter; heat shock promoters; the albumin promoter; the ApoAI promoter; human globin promoters; viral thymidine kinase promoters, such as the Herpes Simplex thymidine kinase promoter; retroviral LTRs; the b-actin
25 promoter; and human growth hormone promoters. The promoter also may be the native promoter for the polynucleotides of the invention.

Unlike other gene therapy techniques, one major advantage of introducing naked nucleic acid sequences into target cells is the transitory nature of the polynucleotide synthesis in the cells. Studies have shown that non-replicating DNA
30 sequences can be introduced into cells to provide production of the desired polypeptide for periods of up to six months.

The polynucleotide construct of the invention can be delivered to the interstitial space of tissues within the an animal, including of muscle, skin, brain, lung, liver, spleen, bone marrow, thymus, heart, lymph, blood, bone, cartilage,
35 pancreas, kidney, gall bladder, stomach, intestine, testis, ovary, uterus, rectum, nervous system, eye, gland, and connective tissue. Interstitial space of the tissues

comprises the intercellular, fluid, mucopolysaccharide matrix among the reticular fibers of organ tissues, elastic fibers in the walls of vessels or chambers, collagen fibers of fibrous tissues, or that same matrix within connective tissue ensheathing muscle cells or in the lacunae of bone. It is similarly the space occupied by the plasma of the circulation and the lymph fluid of the lymphatic channels. Delivery to the interstitial space of muscle tissue is preferred for the reasons discussed below. They may be conveniently delivered by injection into the tissues comprising these cells. They are preferably delivered to and expressed in persistent, non-dividing cells which are differentiated, although delivery and expression may be achieved in non-differentiated or less completely differentiated cells, such as, for example, stem cells of blood or skin fibroblasts. In vivo muscle cells are particularly competent in their ability to take up and express polynucleotides.

For the naked nucleic acid sequence injection, an effective dosage amount of DNA or RNA will be in the range of from about 0.05 mg/kg body weight to about 50 mg/kg body weight. Preferably the dosage will be from about 0.005 mg/kg to about 20 mg/kg and more preferably from about 0.05 mg/kg to about 5 mg/kg. Of course, as the artisan of ordinary skill will appreciate, this dosage will vary according to the tissue site of injection. The appropriate and effective dosage of nucleic acid sequence can readily be determined by those of ordinary skill in the art and may depend on the condition being treated and the route of administration.

The preferred route of administration is by the parenteral route of injection into the interstitial space of tissues. However, other parenteral routes may also be used, such as, inhalation of an aerosol formulation particularly for delivery to lungs or bronchial tissues, throat or mucous membranes of the nose. In addition, naked DNA constructs can be delivered to arteries during angioplasty by the catheter used in the procedure.

The naked polynucleotides are delivered by any method known in the art, including, but not limited to, direct needle injection at the delivery site, intravenous injection, topical administration, catheter infusion, and so-called "gene guns". These delivery methods are known in the art.

The constructs may also be delivered with delivery vehicles such as viral sequences, viral particles, liposome formulations, lipofectin, precipitating agents, etc.

5 Such methods of delivery are known in the art.

In certain embodiments, the polynucleotide constructs of the invention are complexed in a liposome preparation. Liposomal preparations for use in the instant invention include cationic (positively charged), anionic (negatively charged) and neutral preparations. However, cationic liposomes are particularly preferred because a
10 tight charge complex can be formed between the cationic liposome and the polyanionic nucleic acid. Cationic liposomes have been shown to mediate intracellular delivery of plasmid DNA (Felgner et al., Proc. Natl. Acad. Sci. USA , 84:7413-7416 (1987), which is herein incorporated by reference); mRNA (Malone et al., Proc. Natl. Acad. Sci. USA , 86:6077-6081 (1989), which is herein incorporated
15 by reference); and purified transcription factors (Debs et al., J. Biol. Chem..., 265:10189-10192 (1990), which is herein incorporated by reference), in functional form.

Cationic liposomes are readily available. For example, N[1-2,3-dioleoyloxy)propyl]-N,N,N-triethylammonium (DOTMA) liposomes are particularly
20 useful and are available under the trademark Lipofectin, from GIBCO BRL, Grand Island, N.Y. (See, also, Felgner et al., Proc. Natl. Acad. Sci. USA , 84:7413-7416 (1987), which is herein incorporated by reference). Other commercially available liposomes include transfectace (DDAB/DOPE) and DOTAP/DOPE (Boehringer).

Other cationic liposomes can be prepared from readily available materials
25 using techniques well known in the art. See, e.g. PCT Publication NO: WO 90/11092 (which is herein incorporated by reference) for a description of the synthesis of DOTAP (1,2-bis(oleoyloxy)-3-(trimethylammonio)propane) liposomes. Preparation of DOTMA liposomes is explained in the literature, see, e.g., Felgner et al., Proc. Natl. Acad. Sci. USA, 84:7413-7417, which is herein incorporated by reference.
30 Similar methods can be used to prepare liposomes from other cationic lipid materials.

Similarly, anionic and neutral liposomes are readily available, such as from Avanti Polar Lipids (Birmingham, Ala.), or can be easily prepared using readily available materials. Such materials include phosphatidyl, choline, cholesterol, phosphatidyl ethanolamine, dioleoylphosphatidyl choline (DOPC),
35 dioleoylphosphatidyl glycerol (DOPG), dioleoylphosphatidyl ethanolamine (DOPE), among others. These materials can also be mixed with the DOTMA and DOTAP

5 starting materials in appropriate ratios. Methods for making liposomes using these materials are well known in the art.

For example, commercially dioleoylphosphatidyl choline (DOPC),
dioleoylphosphatidyl glycerol (DOPG), and dioleoylphosphatidyl ethanolamine
(DOPE) can be used in various combinations to make conventional liposomes, with or
10 without the addition of cholesterol. Thus, for example, DOPG/DOPC vesicles can be prepared by drying 50 mg each of DOPG and DOPC under a stream of nitrogen gas into a sonication vial. The sample is placed under a vacuum pump overnight and is hydrated the following day with deionized water. The sample is then sonicated for 2
15 hours in a capped vial, using a Heat Systems model 351 sonicator equipped with an inverted cup (bath type) probe at the maximum setting while the bath is circulated at 15EC. Alternatively, negatively charged vesicles can be prepared without sonication to produce multilamellar vesicles or by extrusion through nucleopore membranes to produce unilamellar vesicles of discrete size. Other methods are known and available to those of skill in the art.

20 The liposomes can comprise multilamellar vesicles (MLVs), small unilamellar vesicles (SUVs), or large unilamellar vesicles (LUVs), with SUVs being preferred. The various liposome-nucleic acid complexes are prepared using methods well known in the art. See, e.g., Straubinger et al., *Methods of Immunology*, 101:512-527 (1983), which is herein incorporated by reference. For example, MLVs containing nucleic
25 acid can be prepared by depositing a thin film of phospholipid on the walls of a glass tube and subsequently hydrating with a solution of the material to be encapsulated. SUVs are prepared by extended sonication of MLVs to produce a homogeneous population of unilamellar liposomes. The material to be entrapped is added to a suspension of preformed MLVs and then sonicated. When using liposomes containing
30 cationic lipids, the dried lipid film is resuspended in an appropriate solution such as sterile water or an isotonic buffer solution such as 10 mM Tris/NaCl, sonicated, and then the preformed liposomes are mixed directly with the DNA. The liposome and DNA form a very stable complex due to binding of the positively charged liposomes to the cationic DNA. SUVs find use with small nucleic acid fragments. LUVs are
35 prepared by a number of methods, well known in the art. Commonly used methods include Ca^{2+} -EDTA chelation (Papahadjopoulos et al., *Biochim. Biophys. Acta*,

5 394:483 (1975); Wilson et al., Cell , 17:77 (1979)); ether injection (Deamer et al., Biochim. Biophys. Acta, 443:629 (1976); Ostro et al., Biochem. Biophys. Res. Commun., 76:836 (1977); Fraley et al., Proc. Natl. Acad. Sci. USA, 76:3348 (1979)); detergent dialysis (Enoch et al., Proc. Natl. Acad. Sci. USA , 76:145 (1979)); and reverse-phase evaporation (REV) (Fraley et al., J. Biol. Chem., 255:10431 (1980);
10 Szoka et al., Proc. Natl. Acad. Sci. USA , 75:145 (1978); Schaefer-Ridder et al., Science, 215:166 (1982)), which are herein incorporated by reference.

Generally, the ratio of DNA to liposomes will be from about 10:1 to about 1:10. Preferably, the ration will be from about 5:1 to about 1:5. More preferably, the ration will be about 3:1 to about 1:3. Still more preferably, the ratio will be about 1:1.

15 U.S. Patent NO: 5,676,954 (which is herein incorporated by reference) reports on the injection of genetic material, complexed with cationic liposomes carriers, into mice. U.S. Patent Nos. 4,897,355, 4,946,787, 5,049,386, 5,459,127, 5,589,466, 5,693,622, 5,580,859, 5,703,055, and international publication NO: WO 94/9469 (which are herein incorporated by reference) provide cationic lipids for use in
20 transfecting DNA into cells and mammals. U.S. Patent Nos. 5,589,466, 5,693,622, 5,580,859, 5,703,055, and international publication NO: WO 94/9469 (which are herein incorporated by reference) provide methods for delivering DNA-cationic lipid complexes to mammals.

In certain embodiments, cells are engineered, ex vivo or in vivo, using a
25 retroviral particle containing RNA which comprises a sequence encoding polypeptides of the invention. Retroviruses from which the retroviral plasmid vectors may be derived include, but are not limited to, Moloney Murine Leukemia Virus, spleen necrosis virus, Rous sarcoma Virus, Harvey Sarcoma Virus, avian leukosis virus, gibbon ape leukemia virus, human immunodeficiency virus, Myeloproliferative
30 Sarcoma Virus, and mammary tumor virus.

The retroviral plasmid vector is employed to transduce packaging cell lines to form producer cell lines. Examples of packaging cells which may be transfected include, but are not limited to, the PE501, PA317, R-2, R-AM, PA12, T19-14X, VT-19-17-H2, RCRE, RCRIP, GP+E-86, GP+envAm12, and DAN cell lines as described
35 in Miller, Human Gene Therapy , 1:5-14 (1990), which is incorporated herein by reference in its entirety. The vector may transduce the packaging cells through any

5 means known in the art. Such means include, but are not limited to, electroporation, the use of liposomes, and CaPO₄ precipitation. In one alternative, the retroviral plasmid vector may be encapsulated into a liposome, or coupled to a lipid, and then administered to a host.

The producer cell line generates infectious retroviral vector particles which
10 include polynucleotide encoding polypeptides of the invention. Such retroviral vector particles then may be employed, to transduce eukaryotic cells, either in vitro or in vivo. The transduced eukaryotic cells will express polypeptides of the invention.

In certain other embodiments, cells are engineered, ex vivo or in vivo, with polynucleotides of the invention contained in an adenovirus vector. Adenovirus can
15 be manipulated such that it encodes and expresses polypeptides of the invention, and at the same time is inactivated in terms of its ability to replicate in a normal lytic viral life cycle. Adenovirus expression is achieved without integration of the viral DNA into the host cell chromosome, thereby alleviating concerns about insertional mutagenesis. Furthermore, adenoviruses have been used as live enteric vaccines for
20 many years with an excellent safety profile (Schwartz et al., Am. Rev. Respir. Dis., 109:233-238 (1974)). Finally, adenovirus mediated gene transfer has been demonstrated in a number of instances including transfer of alpha-1-antitrypsin and CFTR to the lungs of cotton rats (Rosenfeld et al., Science, 252:431-434 (1991); Rosenfeld et al., Cell, 68:143-155 (1992)). Furthermore, extensive studies to attempt
25 to establish adenovirus as a causative agent in human cancer were uniformly negative (Green et al. Proc. Natl. Acad. Sci. USA, 76:6606 (1979)).

Suitable adenoviral vectors useful in the present invention are described, for example, in Kozarsky and Wilson, Curr. Opin. Genet. Devel., 3:499-503 (1993); Rosenfeld et al., Cell, 68:143-155 (1992); Engelhardt et al., Human Genet. Ther.,
30 4:759-769 (1993); Yang et al., Nature Genet., 7:362-369 (1994); Wilson et al., Nature, 365:691-692 (1993); and U.S. Patent NO: 5,652,224, which are herein incorporated by reference. For example, the adenovirus vector Ad2 is useful and can be grown in human 293 cells. These cells contain the E1 region of adenovirus and constitutively express Ela and Elb, which complement the defective adenoviruses by providing the
35 products of the genes deleted from the vector. In addition to Ad2, other varieties of adenovirus (e.g., Ad3, Ad5, and Ad7) are also useful in the present invention.

5 Preferably, the adenoviruses used in the present invention are replication deficient. Replication deficient adenoviruses require the aid of a helper virus and/or packaging cell line to form infectious particles. The resulting virus is capable of infecting cells and can express a polynucleotide of interest which is operably linked to a promoter, but cannot replicate in most cells. Replication deficient adenoviruses may
10 be deleted in one or more of all or a portion of the following genes: E1a, E1b, E3, E4, E2a, or L1 through L5.

 In certain other embodiments, the cells are engineered, *ex vivo* or *in vivo*, using an adeno-associated virus (AAV). AAVs are naturally occurring defective viruses that require helper viruses to produce infectious particles (Muzyczka, Curr.
15 Topics in Microbiol. Immunol., 158:97 (1992)). It is also one of the few viruses that may integrate its DNA into non-dividing cells. Vectors containing as little as 300 base pairs of AAV can be packaged and can integrate, but space for exogenous DNA is limited to about 4.5 kb. Methods for producing and using such AAVs are known in the art. See, for example, U.S. Patent Nos. 5,139,941, 5,173,414, 5,354,678,
20 5,436,146, 5,474,935, 5,478,745, and 5,589,377.

 For example, an appropriate AAV vector for use in the present invention will include all the sequences necessary for DNA replication, encapsidation, and host-cell integration. The polynucleotide construct containing polynucleotides of the invention is inserted into the AAV vector using standard cloning methods, such as those found
25 in Sambrook et al., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press (1989). The recombinant AAV vector is then transfected into packaging cells which are infected with a helper virus, using any standard technique, including lipofection, electroporation, calcium phosphate precipitation, etc. Appropriate helper viruses include adenoviruses, cytomegaloviruses, vaccinia viruses, or herpes viruses.
30 Once the packaging cells are transfected and infected, they will produce infectious AAV viral particles which contain the polynucleotide construct of the invention. These viral particles are then used to transduce eukaryotic cells, either *ex vivo* or *in vivo*. The transduced cells will contain the polynucleotide construct integrated into its genome, and will express the desired gene product.

35 Another method of gene therapy involves operably associating heterologous control regions and endogenous polynucleotide sequences (e.g. encoding the

5 polypeptide sequence of interest) via homologous recombination (see, e.g., U.S. Patent NO: 5,641,670, issued June 24, 1997; International Publication NO: WO 96/29411, published September 26, 1996; International Publication NO: WO 94/12650, published August 4, 1994; Koller et al., Proc. Natl. Acad. Sci. USA, 86:8932-8935 (1989); and Zijlstra et al., Nature, 342:435-438 (1989). This method
10 involves the activation of a gene which is present in the target cells, but which is not normally expressed in the cells, or is expressed at a lower level than desired.

Polynucleotide constructs are made, using standard techniques known in the art, which contain the promoter with targeting sequences flanking the promoter. Suitable promoters are described herein. The targeting sequence is sufficiently
15 complementary to an endogenous sequence to permit homologous recombination of the promoter-targeting sequence with the endogenous sequence. The targeting sequence will be sufficiently near the 5' end of the desired endogenous polynucleotide sequence so the promoter will be operably linked to the endogenous sequence upon homologous recombination.

20 The promoter and the targeting sequences can be amplified using PCR. Preferably, the amplified promoter contains distinct restriction enzyme sites on the 5' and 3' ends. Preferably, the 3' end of the first targeting sequence contains the same restriction enzyme site as the 5' end of the amplified promoter and the 5' end of the second targeting sequence contains the same restriction site as the 3' end of the
25 amplified promoter. The amplified promoter and targeting sequences are digested and ligated together.

The promoter-targeting sequence construct is delivered to the cells, either as naked polynucleotide, or in conjunction with transfection-facilitating agents, such as liposomes, viral sequences, viral particles, whole viruses, lipofection, precipitating
30 agents, etc., described in more detail above. The P promoter-targeting sequence can be delivered by any method, included direct needle injection, intravenous injection, topical administration, catheter infusion, particle accelerators, etc. The methods are described in more detail below.

The promoter-targeting sequence construct is taken up by cells. Homologous
35 recombination between the construct and the endogenous sequence takes place, such that an endogenous sequence is placed under the control of the promoter. The

5 promoter then drives the expression of the endogenous sequence.

The polynucleotides encoding polypeptides of the present invention may be administered along with other polynucleotides encoding angiogenic proteins. Angiogenic proteins include, but are not limited to, acidic and basic fibroblast growth factors, VEGF-1, VEGF-2 (VEGF-C), VEGF-3 (VEGF-B), epidermal growth factor
10 alpha and beta, platelet-derived endothelial cell growth factor, platelet-derived growth factor, tumor necrosis factor alpha, hepatocyte growth factor, insulin like growth factor, colony stimulating factor, macrophage colony stimulating factor, granulocyte/macrophage colony stimulating factor, and nitric oxide synthase.

Preferably, the polynucleotide encoding a polypeptide of the invention
15 contains a secretory signal sequence that facilitates secretion of the protein. Typically, the signal sequence is positioned in the coding region of the polynucleotide to be expressed towards or at the 5' end of the coding region. The signal sequence may be homologous or heterologous to the polynucleotide of interest and may be homologous or heterologous to the cells to be transfected. Additionally, the signal sequence may
20 be chemically synthesized using methods known in the art.

Any mode of administration of any of the above-described polynucleotides constructs can be used so long as the mode results in the expression of one or more molecules in an amount sufficient to provide a therapeutic effect. This includes direct needle injection, systemic injection, catheter infusion, biolistic injectors, particle
25 accelerators (i.e., "gene guns"), gelfoam sponge depots, other commercially available depot materials, osmotic pumps (e.g., Alza minipumps), oral or suppositorial solid (tablet or pill) pharmaceutical formulations, and decanting or topical applications during surgery. For example, direct injection of naked calcium phosphate-precipitated plasmid into rat liver and rat spleen or a protein-coated plasmid into the portal vein
30 has resulted in gene expression of the foreign gene in the rat livers. (Kancda et al., Science, 243:375 (1989)).

A preferred method of local administration is by direct injection. Preferably, a recombinant molecule of the present invention complexed with a delivery vehicle is administered by direct injection into or locally within the area of arteries.
35 Administration of a composition locally within the area of arteries refers to injecting the composition centimeters and preferably, millimeters within arteries.

5 Another method of local administration is to contact a polynucleotide construct of the present invention in or around a surgical wound. For example, a patient can undergo surgery and the polynucleotide construct can be coated on the surface of tissue inside the wound or the construct can be injected into areas of tissue inside the wound.

10 Therapeutic compositions useful in systemic administration, include recombinant molecules of the present invention complexed to a targeted delivery vehicle of the present invention. Suitable delivery vehicles for use with systemic administration comprise liposomes comprising ligands for targeting the vehicle to a particular site.

15 Preferred methods of systemic administration, include intravenous injection, aerosol, oral and percutaneous (topical) delivery. Intravenous injections can be performed using methods standard in the art. Aerosol delivery can also be performed using methods standard in the art (see, for example, Stribling et al., Proc. Natl. Acad. Sci. USA , 189:11277-11281 (1992), which is incorporated herein by reference). Oral
20 delivery can be performed by complexing a polynucleotide construct of the present invention to a carrier capable of withstanding degradation by digestive enzymes in the gut of an animal. Examples of such carriers, include plastic capsules or tablets, such as those known in the art. Topical delivery can be performed by mixing a polynucleotide construct of the present invention with a lipophilic reagent (e.g.,
25 DMSO) that is capable of passing into the skin.

 Determining an effective amount of substance to be delivered can depend upon a number of factors including, for example, the chemical structure and biological activity of the substance, the age and weight of the animal, the precise condition requiring treatment and its severity, and the route of administration. The
30 frequency of treatments depends upon a number of factors, such as the amount of polynucleotide constructs administered per dose, as well as the health and history of the subject. The precise amount, number of doses, and timing of doses will be determined by the attending physician or veterinarian. Therapeutic compositions of the present invention can be administered to any animal, preferably to mammals and
35 birds. Preferred mammals include humans, dogs, cats, mice, rats, rabbits sheep, cattle, horses and pigs, with humans being particularly preferred.

5

Biological Activities

The polynucleotides or polypeptides, or agonists or antagonists of the present invention can be used in assays to test for one or more biological activities. If these polynucleotides and polypeptides do exhibit activity in a particular assay, it is likely that these molecules may be involved in the diseases associated with the biological activity. Thus, the polynucleotides or polypeptides, or agonists or antagonists could be used to treat the associated disease.

Immune Activity

The polynucleotides or polypeptides, or agonists or antagonists of the present invention may be useful in treating, preventing, and/or diagnosing diseases, disorders, and/or conditions of the immune system, by activating or inhibiting the proliferation, differentiation, or mobilization (chemotaxis) of immune cells. Immune cells develop through a process called hematopoiesis, producing myeloid (platelets, red blood cells, neutrophils, and macrophages) and lymphoid (B and T lymphocytes) cells from pluripotent stem cells. The etiology of these immune diseases, disorders, and/or conditions may be genetic, somatic, such as cancer or some autoimmune diseases, disorders, and/or conditions, acquired (e.g., by chemotherapy or toxins), or infectious. Moreover, a polynucleotides or polypeptides, or agonists or antagonists of the present invention can be used as a marker or detector of a particular immune system disease or disorder.

A polynucleotides or polypeptides, or agonists or antagonists of the present invention may be useful in treating, preventing, and/or diagnosing diseases, disorders, and/or conditions of hematopoietic cells. A polynucleotides or polypeptides, or agonists or antagonists of the present invention could be used to increase differentiation and proliferation of hematopoietic cells, including the pluripotent stem cells, in an effort to treat or prevent those diseases, disorders, and/or conditions associated with a decrease in certain (or many) types hematopoietic cells. Examples of immunologic deficiency syndromes include, but are not limited to: blood protein diseases, disorders, and/or conditions (e.g. agammaglobulinemia, dysgammaglobulinemia), ataxia telangiectasia, common variable immunodeficiency,

5 Digeorge Syndrome, HIV infection, HTLV-BLV infection, leukocyte adhesion deficiency syndrome, lymphopenia, phagocyte bactericidal dysfunction, severe combined immunodeficiency (SCIDs), Wiskott-Aldrich Disorder, anemia, thrombocytopenia, or hemoglobinuria.

Moreover, a polynucleotides or polypeptides, or agonists or antagonists of the
10 present invention could also be used to modulate hemostatic (the stopping of bleeding) or thrombolytic activity (clot formation). For example, by increasing hemostatic or thrombolytic activity, a polynucleotides or polypeptides, or agonists or antagonists of the present invention could be used to treat or prevent blood coagulation diseases, disorders, and/or conditions (e.g., afibrinogenemia, factor
15 deficiencies), blood platelet diseases, disorders, and/or conditions (e.g. thrombocytopenia), or wounds resulting from trauma, surgery, or other causes. Alternatively, a polynucleotides or polypeptides, or agonists or antagonists of the present invention that can decrease hemostatic or thrombolytic activity could be used to inhibit or dissolve clotting. These molecules could be important in the treatment or
20 prevention of heart attacks (infarction), strokes, or scarring.

A polynucleotides or polypeptides, or agonists or antagonists of the present invention may also be useful in treating, preventing, and/or diagnosing autoimmune diseases, disorders, and/or conditions. Many autoimmune diseases, disorders, and/or conditions result from inappropriate recognition of self as foreign material by immune
25 cells. This inappropriate recognition results in an immune response leading to the destruction of the host tissue. Therefore, the administration of a polynucleotides or polypeptides, or agonists or antagonists of the present invention that inhibits an immune response, particularly the proliferation, differentiation, or chemotaxis of T-cells, may be an effective therapy in preventing autoimmune diseases, disorders,
30 and/or conditions.

Examples of autoimmune diseases, disorders, and/or conditions that can be treated, prevented, and/or diagnosed or detected by the present invention include, but are not limited to: Addison's Disease, hemolytic anemia, antiphospholipid syndrome, rheumatoid arthritis, dermatitis, allergic encephalomyelitis, glomerulonephritis,
35 Goodpasture's Syndrome, Graves' Disease, Multiple Sclerosis, Myasthenia Gravis, Neuritis, Ophthalmia, Bullous Pemphigoid, Pemphigus, Polyendocrinopathies,

Similarly, allergic reactions and conditions, such as asthma (particularly allergic asthma) or other respiratory problems, may also be treated, prevented, and/or diagnosed by polynucleotides or polypeptides, or agonists or antagonists of the present invention. Moreover, these molecules can be used to treat anaphylaxis, hypersensitivity to an antigenic molecule, or blood group incompatibility.

Similarly, a polynucleotides or polypeptides, or agonists or antagonists of the present invention may also be used to modulate inflammation. For example, the polypeptide or polynucleotide or agonists or antagonist may inhibit the proliferation and differentiation of cells involved in an inflammatory response. These molecules can be used to treat, prevent, and/or diagnose inflammatory conditions, both chronic and acute conditions, including chronic prostatitis, granulomatous prostatitis and malacoplakia, inflammation associated with infection (e.g., septic shock, sepsis, or systemic inflammatory response syndrome (SIRS)), ischemia-reperfusion injury, endotoxin lethality, arthritis, complement-mediated hyperacute rejection, nephritis, cytokine or chemokine induced lung injury, inflammatory bowel disease, Crohn's disease, or resulting from over production of cytokines (e.g., TNF or IL-1.)

A polynucleotides or polypeptides, or agonists or antagonists of the invention

5 can be used to treat, prevent, and/or diagnose hyperproliferative diseases, disorders, and/or conditions, including neoplasms. A polynucleotides or polypeptides, or agonists or antagonists of the present invention may inhibit the proliferation of the disorder through direct or indirect interactions. Alternatively, a polynucleotides or polypeptides, or agonists or antagonists of the present invention may proliferate other
10 cells which can inhibit the hyperproliferative disorder.

For example, by increasing an immune response, particularly increasing antigenic qualities of the hyperproliferative disorder or by proliferating, differentiating, or mobilizing T-cells, hyperproliferative diseases, disorders, and/or conditions can be treated, prevented, and/or diagnosed. This immune response may be
15 increased by either enhancing an existing immune response, or by initiating a new immune response. Alternatively, decreasing an immune response may also be a method of treating, preventing, and/or diagnosing hyperproliferative diseases, disorders, and/or conditions, such as a chemotherapeutic agent.

Examples of hyperproliferative diseases, disorders, and/or conditions that can
20 be treated, prevented, and/or diagnosed by polynucleotides or polypeptides, or agonists or antagonists of the present invention include, but are not limited to neoplasms located in the: colon, abdomen, bone, breast, digestive system, liver, pancreas, peritoneum, endocrine glands (adrenal, parathyroid, pituitary, testicles, ovary, thymus, thyroid), eye, head and neck, nervous (central and peripheral),
25 lymphatic system, pelvic, skin, soft tissue, spleen, thoracic, and urogenital.

Similarly, other hyperproliferative diseases, disorders, and/or conditions can also be treated, prevented, and/or diagnosed by a polynucleotides or polypeptides, or agonists or antagonists of the present invention. Examples of such hyperproliferative diseases, disorders, and/or conditions include, but are not limited to:
30 hypergammaglobulinemia, lymphoproliferative diseases, disorders, and/or conditions, paraproteinemias, purpura, sarcoidosis, Sezary Syndrome, Waldenström's Macroglobulinemia, Gaucher's Disease, histiocytosis, and any other hyperproliferative disease, besides neoplasia, located in an organ system listed above.

One preferred embodiment utilizes polynucleotides of the present invention to
35 inhibit aberrant cellular division, by gene therapy using the present invention, and/or protein fusions or fragments thereof.

5 Thus, the present invention provides a method for treating or preventing cell proliferative diseases, disorders, and/or conditions by inserting into an abnormally proliferating cell a polynucleotide of the present invention, wherein said polynucleotide represses said expression.

10 Another embodiment of the present invention provides a method of treating or preventing cell-proliferative diseases, disorders, and/or conditions in individuals comprising administration of one or more active gene copies of the present invention to an abnormally proliferating cell or cells. In a preferred embodiment, polynucleotides of the present invention is a DNA construct comprising a recombinant expression vector effective in expressing a DNA sequence encoding said
15 polynucleotides. In another preferred embodiment of the present invention, the DNA construct encoding the polynucleotides of the present invention is inserted into cells to be treated utilizing a retrovirus, or more Preferably an adenoviral vector (See G J. Nabel, et. al., PNAS 1999 96: 324-326, which is hereby incorporated by reference). In a most preferred embodiment, the viral vector is defective and will not transform non-
20 proliferating cells, only proliferating cells. Moreover, in a preferred embodiment, the polynucleotides of the present invention inserted into proliferating cells either alone, or in combination with or fused to other polynucleotides, can then be modulated via an external stimulus (i.e. magnetic, specific small molecule, chemical, or drug administration, etc.), which acts upon the promoter upstream of said polynucleotides
25 to induce expression of the encoded protein product. As such the beneficial therapeutic affect of the present invention may be expressly modulated (i.e. to increase, decrease, or inhibit expression of the present invention) based upon said external stimulus.

30 Polynucleotides of the present invention may be useful in repressing expression of oncogenic genes or antigens. By "repressing expression of the oncogenic genes " is intended the suppression of the transcription of the gene, the degradation of the gene transcript (pre-message RNA), the inhibition of splicing, the destruction of the messenger RNA, the prevention of the post-translational modifications of the protein, the destruction of the protein, or the inhibition of the
35 normal function of the protein.

For local administration to abnormally proliferating cells, polynucleotides of

5 the present invention may be administered by any method known to those of skill in the art including, but not limited to transfection, electroporation, microinjection of cells, or in vehicles such as liposomes, lipofectin, or as naked polynucleotides, or any other method described throughout the specification. The polynucleotide of the present invention may be delivered by known gene delivery systems such as, but not
10 limited to, retroviral vectors (Gilboa, J. Virology 44:845 (1982); Hocke, Nature 320:275 (1986); Wilson, et al., Proc. Natl. Acad. Sci. U.S.A. 85:3014), vaccinia virus system (Chakrabarty et al., Mol. Cell Biol. 5:3403 (1985) or other efficient DNA delivery systems (Yates et al., Nature 313:812 (1985)) known to those skilled in the art. These references are exemplary only and are hereby incorporated by reference. In
15 order to specifically deliver or transfect cells which are abnormally proliferating and spare non-dividing cells, it is preferable to utilize a retrovirus, or adenoviral (as described in the art and elsewhere herein) delivery system known to those of skill in the art. Since host DNA replication is required for retroviral DNA to integrate and the retrovirus will be unable to self replicate due to the lack of the retrovirus genes
20 needed for its life cycle. Utilizing such a retroviral delivery system for polynucleotides of the present invention will target said gene and constructs to abnormally proliferating cells and will spare the non-dividing normal cells.

The polynucleotides of the present invention may be delivered directly to cell proliferative disorder/disease sites in internal organs, body cavities and the like by use
25 of imaging devices used to guide an injecting needle directly to the disease site. The polynucleotides of the present invention may also be administered to disease sites at the time of surgical intervention.

By "cell proliferative disease" is meant any human or animal disease or disorder, affecting any one or any combination of organs, cavities, or body parts,
30 which is characterized by single or multiple local abnormal proliferations of cells, groups of cells, or tissues, whether benign or malignant.

Any amount of the polynucleotides of the present invention may be administered as long as it has a biologically inhibiting effect on the proliferation of the treated cells. Moreover, it is possible to administer more than one of the
35 polynucleotide of the present invention simultaneously to the same site. By "biologically inhibiting" is meant partial or total growth inhibition as well as

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5 decreases in the rate of proliferation or growth of the cells. The biologically inhibitory dose may be determined by assessing the effects of the polynucleotides of the present invention on target malignant or abnormally proliferating cell growth in tissue culture, tumor growth in animals and cell cultures, or any other method known to one of ordinary skill in the art.

10 The present invention is further directed to antibody-based therapies which involve administering of anti-polypeptides and anti-polynucleotide antibodies to a mammalian, preferably human, patient for treating, preventing, and/or diagnosing one or more of the described diseases, disorders, and/or conditions. Methods for producing anti-polypeptides and anti-polynucleotide antibodies polyclonal and
15 monoclonal antibodies are described in detail elsewhere herein. Such antibodies may be provided in pharmaceutically acceptable compositions as known in the art or as described herein.

A summary of the ways in which the antibodies of the present invention may be used therapeutically includes binding polynucleotides or polypeptides of the
20 present invention locally or systemically in the body or by direct cytotoxicity of the antibody, e.g. as mediated by complement (CDC) or by effector cells (ADCC). Some of these approaches are described in more detail below. Armed with the teachings provided herein, one of ordinary skill in the art will know how to use the antibodies of the present invention for diagnostic, monitoring or therapeutic purposes without
25 undue experimentation.

In particular, the antibodies, fragments and derivatives of the present invention are useful for treating, preventing, and/or diagnosing a subject having or developing cell proliferative and/or differentiation diseases, disorders, and/or conditions as described herein. Such treatment comprises administering a single or multiple doses
30 of the antibody, or a fragment, derivative, or a conjugate thereof.

The antibodies of this invention may be advantageously utilized in combination with other monoclonal or chimeric antibodies, or with lymphokines or hematopoietic growth factors, for example, which serve to increase the number or activity of effector cells which interact with the antibodies.

35 It is preferred to use high affinity and/or potent in vivo inhibiting and/or neutralizing antibodies against polypeptides or polynucleotides of the present

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5 invention, fragments or regions thereof, for both immunoassays directed to and therapy of diseases, disorders, and/or conditions related to polynucleotides or polypeptides, including fragments thereof, of the present invention. Such antibodies, fragments, or regions, will preferably have an affinity for polynucleotides or polypeptides, including fragments thereof. Preferred binding affinities include those
10 with a dissociation constant or K_d less than $5 \times 10^{-6}M$, $10^{-6}M$, $5 \times 10^{-7}M$, $10^{-7}M$, $5 \times 10^{-8}M$, $10^{-8}M$, $5 \times 10^{-9}M$, $10^{-9}M$, $5 \times 10^{-10}M$, $10^{-10}M$, $5 \times 10^{-11}M$, $10^{-11}M$, $5 \times 10^{-12}M$, $10^{-12}M$, $5 \times 10^{-13}M$, $10^{-13}M$, $5 \times 10^{-14}M$, $10^{-14}M$, $5 \times 10^{-15}M$, and $10^{-15}M$.

Moreover, polypeptides of the present invention may be useful in inhibiting
15 the angiogenesis of proliferative cells or tissues, either alone, as a protein fusion, or in combination with other polypeptides directly or indirectly, as described elsewhere herein. In a most preferred embodiment, said anti-angiogenesis effect may be achieved indirectly, for example, through the inhibition of hematopoietic, tumor-specific cells, such as tumor-associated macrophages (See Joseph IB, et al. J Natl
20 Cancer Inst, 90(21):1648-53 (1998), which is hereby incorporated by reference). Antibodies directed to polypeptides or polynucleotides of the present invention may also result in inhibition of angiogenesis directly, or indirectly (See Witte L, et al., Cancer Metastasis Rev. 17(2):155-61 (1998), which is hereby incorporated by reference)).

25 Polypeptides, including protein fusions, of the present invention, or fragments thereof may be useful in inhibiting proliferative cells or tissues through the induction of apoptosis. Said polypeptides may act either directly, or indirectly to induce apoptosis of proliferative cells and tissues, for example in the activation of a death-domain receptor, such as tumor necrosis factor (TNF) receptor-1, CD95 (Fas/APO-1),
30 TNF-receptor-related apoptosis-mediated protein (TRAMP) and TNF-related apoptosis-inducing ligand (TRAIL) receptor-1 and -2 (See Schulze-Osthoff K, et al., Eur J Biochem 254(3):439-59 (1998), which is hereby incorporated by reference). Moreover, in another preferred embodiment of the present invention, said polypeptides may induce apoptosis through other mechanisms, such as in the
35 activation of other proteins which will activate apoptosis, or through stimulating the expression of said proteins, either alone or in combination with small molecule drugs

5 or adjuvants, such as apoptonin, galectins, thioredoxins, antiinflammatory proteins (See for example, Mutat. Res. 400(1-2):447-55 (1998), Med Hypotheses.50(5):423-33 (1998), Chem. Biol. Interact. Apr 24;111-112:23-34 (1998), J Mol Med.76(6):402-12 (1998), Int. J. Tissue React. 20(1):3-15 (1998), which are all hereby incorporated by reference).

Polypeptides, including protein fusions to, or fragments thereof, of the present invention are useful in inhibiting the metastasis of proliferative cells or tissues. Inhibition may occur as a direct result of administering polypeptides, or antibodies directed to said polypeptides as described elsewhere herein, or indirectly, such as activating the expression of proteins known to inhibit metastasis, for example alpha 4 integrins, (See, e.g., Curr Top Microbiol Immunol 1998;231:125-41, which is hereby incorporated by reference). Such therapeutic affects of the present invention may be achieved either alone, or in combination with small molecule drugs or adjuvants.

In another embodiment, the invention provides a method of delivering compositions containing the polypeptides of the invention (e.g., compositions containing polypeptides or polypeptide antibodies associated with heterologous polypeptides, heterologous nucleic acids, toxins, or prodrugs) to targeted cells expressing the polypeptide of the present invention. Polypeptides or polypeptide antibodies of the invention may be associated with heterologous polypeptides, heterologous nucleic acids, toxins, or prodrugs via hydrophobic, hydrophilic, ionic and/or covalent interactions.

Polypeptides, protein fusions to, or fragments thereof, of the present invention are useful in enhancing the immunogenicity and/or antigenicity of proliferating cells or tissues, either directly, such as would occur if the polypeptides of the present invention ‘vaccinated’ the immune response to respond to proliferative antigens and immunogens, or indirectly, such as in activating the expression of proteins known to enhance the immune response (e.g. chemokines), to said antigens and immunogens.

Cardiovascular Disorders

Polynucleotides or polypeptides, or agonists or antagonists of the invention
35 may be used to treat, prevent, and/or diagnose cardiovascular diseases, disorders,
and/or conditions, including peripheral artery disease, such as limb ischemia.

Cardiovascular diseases, disorders, and/or conditions also include heart disease, such as arrhythmias, carcinoid heart disease, high cardiac output, low cardiac output, cardiac tamponade, endocarditis (including bacterial), heart aneurysm, cardiac arrest, congestive heart failure, congestive cardiomyopathy, paroxysmal dyspnea, cardiac edema, heart hypertrophy, congestive cardiomyopathy, left ventricular hypertrophy, right ventricular hypertrophy, post-infarction heart rupture, ventricular septal rupture, heart valve diseases, myocardial diseases, myocardial ischemia, pericardial effusion, pericarditis (including constrictive and tuberculous), pneumopericardium, postpericardiotomy syndrome, pulmonary heart disease, rheumatic heart disease, ventricular dysfunction, hyperemia, cardiovascular pregnancy complications, Scimitar Syndrome, cardiovascular syphilis, and cardiovascular tuberculosis.

Heart valve disease include aortic valve insufficiency, aortic valve stenosis,

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5 hear murmurs, aortic valve prolapse, mitral valve prolapse, tricuspid valve prolapse, mitral valve insufficiency, mitral valve stenosis, pulmonary atresia, pulmonary valve insufficiency, pulmonary valve stenosis, tricuspid atresia, tricuspid valve insufficiency, and tricuspid valve stenosis.

Myocardial diseases include alcoholic cardiomyopathy, congestive
10 cardiomyopathy, hypertrophic cardiomyopathy, aortic subvalvular stenosis, pulmonary subvalvular stenosis, restrictive cardiomyopathy, Chagas cardiomyopathy, endocardial fibroelastosis, endomyocardial fibrosis, Kearns Syndrome, myocardial reperfusion injury, and myocarditis.

Myocardial ischemias include coronary disease, such as angina pectoris,
15 coronary aneurysm, coronary arteriosclerosis, coronary thrombosis, coronary vasospasm, myocardial infarction and myocardial stunning.

Cardiovascular diseases also include vascular diseases such as aneurysms, angiodyplasia, angiomatosis, bacillary angiomatosis, Hippel-Lindau Disease, Klippel-Trenaunay-Weber Syndrome, Sturge-Weber Syndrome, angioneurotic edema,
20 aortic diseases, Takayasu's Arteritis, aortitis, Leriche's Syndrome, arterial occlusive diseases, arteritis, enarteritis, polyarteritis nodosa, cerebrovascular diseases, disorders, and/or conditions, diabetic angiopathies, diabetic retinopathy, embolisms, thrombosis, erythromelalgia, hemorrhoids, hepatic veno-occlusive disease, hypertension, hypotension, ischemia, peripheral vascular diseases, phlebitis, pulmonary veno-
25 occlusive disease, Raynaud's disease, CREST syndrome, retinal vein occlusion, Scimitar syndrome, superior vena cava syndrome, telangiectasia, atacia telangiectasia, hereditary hemorrhagic telangiectasia, varicocele, varicose veins, varicose ulcer, vasculitis, and venous insufficiency.

Aneurysms include dissecting aneurysms, false aneurysms, infected
30 aneurysms, ruptured aneurysms, aortic aneurysms, cerebral aneurysms, coronary aneurysms, heart aneurysms, and iliac aneurysms.

Arterial occlusive diseases include arteriosclerosis, intermittent claudication, carotid stenosis, fibromuscular dysplasias, mesenteric vascular occlusion, Moyamoya disease, renal artery obstruction, retinal artery occlusion, and thromboangiitis
35 obliterans.

Cerebrovascular diseases, disorders, and/or conditions include carotid artery

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5 diseases, cerebral amyloid angiopathy, cerebral aneurysm, cerebral anoxia, cerebral arteriosclerosis, cerebral arteriovenous malformation, cerebral artery diseases, cerebral embolism and thrombosis, carotid artery thrombosis, sinus thrombosis, Wallenberg's syndrome, cerebral hemorrhage, epidural hematoma, subdural
10 (including transient), subclavian steal syndrome, periventricular leukomalacia, vascular headache, cluster headache, migraine, and vertebrobasilar insufficiency.

Embolisms include air embolisms, amniotic fluid embolisms, cholesterol embolisms, blue toe syndrome, fat embolisms, pulmonary embolisms, and thromboembolisms. Thrombosis include coronary thrombosis, hepatic vein
15 thrombosis, retinal vein occlusion, carotid artery thrombosis, sinus thrombosis, Wallenberg's syndrome, and thrombophlebitis.

Ischemia includes cerebral ischemia, ischemic colitis, compartment syndromes, anterior compartment syndrome, myocardial ischemia, reperfusion injuries, and peripheral limb ischemia. Vasculitis includes aortitis, arteritis, Behcet's
20 Syndrome, Churg-Strauss Syndrome, mucocutaneous lymph node syndrome, thromboangiitis obliterans, hypersensitivity vasculitis, Schoenlein-Henoch purpura, allergic cutaneous vasculitis, and Wegener's granulomatosis.

Polynucleotides or polypeptides, or agonists or antagonists of the invention, are especially effective for the treatment of critical limb ischemia and coronary
25 disease.

Polypeptides may be administered using any method known in the art, including, but not limited to, direct needle injection at the delivery site, intravenous injection, topical administration, catheter infusion, biolistic injectors, particle accelerators, gelfoam sponge depots, other commercially available depot materials,
30 osmotic pumps, oral or suppository solid pharmaceutical formulations, decanting or topical applications during surgery, aerosol delivery. Such methods are known in the art. Polypeptides of the invention may be administered as part of a Therapeutic, described in more detail below. Methods of delivering polynucleotides of the invention are described in more detail herein.

35

5 **Diseases at the Cellular Level**

Diseases associated with increased cell survival or the inhibition of apoptosis that could be treated, prevented, and/or diagnosed by the polynucleotides or polypeptides and/or antagonists or agonists of the invention, include cancers (such as follicular lymphomas, carcinomas with p53 mutations, and hormone-dependent
10 tumors, including, but not limited to colon cancer, cardiac tumors, pancreatic cancer, melanoma, retinoblastoma, glioblastoma, lung cancer, intestinal cancer, testicular cancer, stomach cancer, neuroblastoma, myxoma, myoma, lymphoma, endothelioma, osteoblastoma, osteoclastoma, osteosarcoma, chondrosarcoma, adenoma, breast cancer, prostate cancer, Kaposi's sarcoma and ovarian cancer); autoimmune diseases,
15 disorders, and/or conditions (such as, multiple sclerosis, Sjogren's syndrome, Hashimoto's thyroiditis, biliary cirrhosis, Behcet's disease, Crohn's disease, polymyositis, systemic lupus erythematosus and immune-related glomerulonephritis and rheumatoid arthritis) and viral infections (such as herpes viruses, pox viruses and adenoviruses), inflammation, graft v. host disease, acute graft rejection, and chronic
20 graft rejection. In preferred embodiments, the polynucleotides or polypeptides, and/or agonists or antagonists of the invention are used to inhibit growth, progression, and/or metastasis of cancers, in particular those listed above.

Additional diseases or conditions associated with increased cell survival that could be treated, prevented or diagnosed by the polynucleotides or polypeptides, or
25 agonists or antagonists of the invention, include, but are not limited to, progression, and/or metastases of malignancies and related disorders such as leukemia (including acute leukemias (e.g., acute lymphocytic leukemia, acute myelocytic leukemia (including myeloblastic, promyelocytic, myelomonocytic, monocytic, and erythroleukemia)) and chronic leukemias (e.g., chronic myelocytic (granulocytic)
30 leukemia and chronic lymphocytic leukemia)), polycythemia vera, lymphomas (e.g., Hodgkin's disease and non-Hodgkin's disease), multiple myeloma, Waldenstrom's macroglobulinemia, heavy chain disease, and solid tumors including, but not limited to, sarcomas and carcinomas such as fibrosarcoma, myxosarcoma, liposarcoma, chondrosarcoma, osteogenic sarcoma, chordoma, angiosarcoma, endotheliosarcoma,
35 lymphangiosarcoma, lymphangioendotheliosarcoma, synovioma, mesothelioma, Ewing's tumor, leiomyosarcoma, rhabdomyosarcoma, colon carcinoma, pancreatic

5 cancer, breast cancer, ovarian cancer, prostate cancer, squamous cell carcinoma, basal
cell carcinoma, adenocarcinoma, sweat gland carcinoma, sebaceous gland carcinoma,
papillary carcinoma, papillary adenocarcinomas, cystadenocarcinoma, medullary
carcinoma, bronchogenic carcinoma, renal cell carcinoma, hepatoma, bile duct
10 carcinoma, choriocarcinoma, seminoma, embryonal carcinoma, Wilm's tumor,
cervical cancer, testicular tumor, lung carcinoma, small cell lung carcinoma, bladder
carcinoma, epithelial carcinoma, glioma, astrocytoma, medulloblastoma,
craniopharyngioma, ependymoma, pinealoma, hemangioblastoma, acoustic neuroma,
oligodendroglioma, meningioma, melanoma, neuroblastoma, and retinoblastoma.

Diseases associated with increased apoptosis that could be treated, prevented,
15 and/or diagnosed by the polynucleotides or polypeptides, and/or agonists or
antagonists of the invention, include AIDS; neurodegenerative diseases, disorders,
and/or conditions (such as Alzheimer's disease, Parkinson's disease, Amyotrophic
lateral sclerosis, Retinitis pigmentosa, Cerebellar degeneration and brain tumor or
prior associated disease); autoimmune diseases, disorders, and/or conditions (such as,
20 multiple sclerosis, Sjogren's syndrome, Hashimoto's thyroiditis, biliary cirrhosis,
Behcet's disease, Crohn's disease, polymyositis, systemic lupus erythematosus and
immune-related glomerulonephritis and rheumatoid arthritis) myelodysplastic
syndromes (such as aplastic anemia), graft v. host disease, ischemic injury (such as
that caused by myocardial infarction, stroke and reperfusion injury), liver injury (e.g.,
25 hepatitis related liver injury, ischemia/reperfusion injury, cholestasis (bile duct injury)
and liver cancer); toxin-induced liver disease (such as that caused by alcohol), septic
shock, cachexia and anorexia.

Wound Healing and Epithelial Cell Proliferation

30 In accordance with yet a further aspect of the present invention, there is
provided a process for utilizing the polynucleotides or polypeptides, and/or agonists
or antagonists of the invention, for therapeutic purposes, for example, to stimulate
epithelial cell proliferation and basal keratinocytes for the purpose of wound healing,
and to stimulate hair follicle production and healing of dermal wounds.
35 Polynucleotides or polypeptides, as well as agonists or antagonists of the invention,
may be clinically useful in stimulating wound healing including surgical wounds,

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5 excisional wounds, deep wounds involving damage of the dermis and epidermis, eye
tissue wounds, dental tissue wounds, oral cavity wounds, diabetic ulcers, dermal
ulcers, cubitus ulcers, arterial ulcers, venous stasis ulcers, burns resulting from heat
exposure or chemicals, and other abnormal wound healing conditions such as uremia,
malnutrition, vitamin deficiencies and complications associated with systemic
10 treatment with steroids, radiation therapy and antineoplastic drugs and
antimetabolites. Polynucleotides or polypeptides, and/or agonists or antagonists of the
invention, could be used to promote dermal reestablishment subsequent to dermal loss

The polynucleotides or polypeptides, and/or agonists or antagonists of the
invention, could be used to increase the adherence of skin grafts to a wound bed and
15 to stimulate re-epithelialization from the wound bed. The following are a non-
exhaustive list of grafts that polynucleotides or polypeptides, agonists or antagonists
of the invention, could be used to increase adherence to a wound bed: autografts,
artificial skin, allografts, autodermic graft, autoepidermic grafts, avacular grafts,
Blair-Brown grafts, bone graft, brephoplastic grafts, cutis graft, delayed graft, dermic
20 graft, epidermic graft, fascia graft, full thickness graft, heterologous graft, xenograft,
homologous graft, hyperplastic graft, lamellar graft, mesh graft, mucosal graft, Ollier-
Thiersch graft, omentopial graft, patch graft, pedicle graft, penetrating graft, split skin
graft, thick split graft. The polynucleotides or polypeptides, and/or agonists or
antagonists of the invention, can be used to promote skin strength and to improve the
25 appearance of aged skin.

It is believed that the polynucleotides or polypeptides, and/or agonists or
antagonists of the invention, will also produce changes in hepatocyte proliferation,
and epithelial cell proliferation in the lung, breast, pancreas, stomach, small intestine,
and large intestine. The polynucleotides or polypeptides, and/or agonists or
30 antagonists of the invention, could promote proliferation of epithelial cells such as
sebocytes, hair follicles, hepatocytes, type II pneumocytes, mucin-producing goblet
cells, and other epithelial cells and their progenitors contained within the skin, lung,
liver, and gastrointestinal tract. The polynucleotides or polypeptides, and/or agonists
or antagonists of the invention, may promote proliferation of endothelial cells,
35 keratinocytes, and basal keratinocytes.

The polynucleotides or polypeptides, and/or agonists or antagonists of the

5 invention, could also be used to reduce the side effects of gut toxicity that result from radiation, chemotherapy treatments or viral infections. The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, may have a cytoprotective effect on the small intestine mucosa. The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, may also stimulate
10 healing of mucositis (mouth ulcers) that result from chemotherapy and viral infections.

The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could further be used in full regeneration of skin in full and partial thickness skin defects, including burns, (i.e., repopulation of hair follicles, sweat
15 glands, and sebaceous glands), treatment of other skin defects such as psoriasis. The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to treat epidermolysis bullosa, a defect in adherence of the epidermis to the underlying dermis which results in frequent, open and painful blisters by accelerating reepithelialization of these lesions. The polynucleotides or polypeptides, and/or
20 agonists or antagonists of the invention, could also be used to treat gastric and duodenal ulcers and help heal by scar formation of the mucosal lining and regeneration of glandular mucosa and duodenal mucosal lining more rapidly. Inflammatory bowel diseases, such as Crohn's disease and ulcerative colitis, are diseases which result in destruction of the mucosal surface of the small or large
25 intestine, respectively. Thus, the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to promote the resurfacing of the mucosal surface to aid more rapid healing and to prevent progression of inflammatory bowel disease. Treatment with the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, is expected to have a significant effect on the production
30 of mucus throughout the gastrointestinal tract and could be used to protect the intestinal mucosa from injurious substances that are ingested or following surgery. The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to treat diseases associate with the under expression of the polynucleotides of the invention.

35 Moreover, the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to prevent and heal damage to the lungs due to various

5 pathological states. A growth factor such as the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, which could stimulate proliferation and differentiation and promote the repair of alveoli and bronchiolar epithelium to prevent or treat acute or chronic lung damage. For example, emphysema, which results in the progressive loss of alveoli, and inhalation injuries, i.e., resulting from
10 smoke inhalation and burns, that cause necrosis of the bronchiolar epithelium and alveoli could be effectively treated, prevented, and/or diagnosed using the polynucleotides or polypeptides, and/or agonists or antagonists of the invention. Also, the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to stimulate the proliferation of and differentiation of type II
15 pneumocytes, which may help treat or prevent disease such as hyaline membrane diseases, such as infant respiratory distress syndrome and bronchopulmonary dysplasia, in premature infants.

The polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could stimulate the proliferation and differentiation of hepatocytes and,
20 thus, could be used to alleviate or treat liver diseases and pathologies such as fulminant liver failure caused by cirrhosis, liver damage caused by viral hepatitis and toxic substances (i.e., acetaminophen, carbon tetrachloride and other hepatotoxins known in the art).

In addition, the polynucleotides or polypeptides, and/or agonists or antagonists
25 of the invention, could be used to treat or prevent the onset of diabetes mellitus. In patients with newly diagnosed Types I and II diabetes, where some islet cell function remains, the polynucleotides or polypeptides, and/or agonists or antagonists of the invention, could be used to maintain the islet function so as to alleviate, delay or prevent permanent manifestation of the disease. Also, the polynucleotides or
30 polypeptides, and/or agonists or antagonists of the invention, could be used as an auxiliary in islet cell transplantation to improve or promote islet cell function.

Neurological Diseases

Nervous system diseases, disorders, and/or conditions, which can be treated,
35 prevented, and/or diagnosed with the compositions of the invention (e.g., polypeptides, polynucleotides, and/or agonists or antagonists), include, but are not

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5 limited to, nervous system injuries, and diseases, disorders, and/or conditions which result in either a disconnection of axons, a diminution or degeneration of neurons, or demyelination. Nervous system lesions which may be treated, prevented, and/or diagnosed in a patient (including human and non-human mammalian patients) according to the invention, include but are not limited to, the following lesions of

10 either the central (including spinal cord, brain) or peripheral nervous systems: (1) ischemic lesions, in which a lack of oxygen in a portion of the nervous system results in neuronal injury or death, including cerebral infarction or ischemia, or spinal cord infarction or ischemia; (2) traumatic lesions, including lesions caused by physical injury or associated with surgery, for example, lesions which sever a portion of the

15 nervous system, or compression injuries; (3) malignant lesions, in which a portion of the nervous system is destroyed or injured by malignant tissue which is either a nervous system associated malignancy or a malignancy derived from non-nervous system tissue; (4) infectious lesions, in which a portion of the nervous system is destroyed or injured as a result of infection, for example, by an abscess or associated

20 with infection by human immunodeficiency virus, herpes zoster, or herpes simplex virus or with Lyme disease, tuberculosis, syphilis; (5) degenerative lesions, in which a portion of the nervous system is destroyed or injured as a result of a degenerative process including but not limited to degeneration associated with Parkinson's disease, Alzheimer's disease, Huntington's chorea, or amyotrophic lateral sclerosis (ALS); (6)

25 lesions associated with nutritional diseases, disorders, and/or conditions, in which a portion of the nervous system is destroyed or injured by a nutritional disorder or disorder of metabolism including but not limited to, vitamin B12 deficiency, folic acid deficiency, Wernicke disease, tobacco-alcohol amblyopia, Marchiafava-Bignami disease (primary degeneration of the corpus callosum), and alcoholic cerebellar

30 degeneration; (7) neurological lesions associated with systemic diseases including, but not limited to, diabetes (diabetic neuropathy, Bell's palsy), systemic lupus erythematosus, carcinoma, or sarcoidosis; (8) lesions caused by toxic substances including alcohol, lead, or particular neurotoxins; and (9) demyelinated lesions in which a portion of the nervous system is destroyed or injured by a demyelinating

35 disease including, but not limited to, multiple sclerosis, human immunodeficiency virus-associated myelopathy, transverse myelopathy or various etiologies, progressive

5 multifocal leukoencephalopathy, and central pontine myelinolysis.

In a preferred embodiment, the polypeptides, polynucleotides, or agonists or antagonists of the invention are used to protect neural cells from the damaging effects of cerebral hypoxia. According to this embodiment, the compositions of the invention are used to treat, prevent, and/or diagnose neural cell injury associated with cerebral
10 hypoxia. In one aspect of this embodiment, the polypeptides, polynucleotides, or agonists or antagonists of the invention are used to treat, prevent, and/or diagnose neural cell injury associated with cerebral ischemia. In another aspect of this embodiment, the polypeptides, polynucleotides, or agonists or antagonists of the invention are used to treat, prevent, and/or diagnose neural cell injury associated with
15 cerebral infarction. In another aspect of this embodiment, the polypeptides, polynucleotides, or agonists or antagonists of the invention are used to treat, prevent, and/or diagnose or prevent neural cell injury associated with a stroke. In a further aspect of this embodiment, the polypeptides, polynucleotides, or agonists or antagonists of the invention are used to treat, prevent, and/or diagnose neural cell
20 injury associated with a heart attack.

The compositions of the invention which are useful for treating or preventing a nervous system disorder may be selected by testing for biological activity in promoting the survival or differentiation of neurons. For example, and not by way of limitation, compositions of the invention which elicit any of the following effects may
25 be useful according to the invention: (1) increased survival time of neurons in culture; (2) increased sprouting of neurons in culture or in vivo; (3) increased production of a neuron-associated molecule in culture or in vivo, e.g., choline acetyltransferase or acetylcholinesterase with respect to motor neurons; or (4) decreased symptoms of neuron dysfunction in vivo. Such effects may be measured by any method known in
30 the art. In preferred, non-limiting embodiments, increased survival of neurons may routinely be measured using a method set forth herein or otherwise known in the art, such as, for example, the method set forth in Arakawa et al. (J. Neurosci. 10:3507-3515 (1990)); increased sprouting of neurons may be detected by methods known in the art, such as, for example, the methods set forth in Pestronk et al. (Exp. Neurol.
35 70:65-82 (1980)) or Brown et al. (Ann. Rev. Neurosci. 4:17-42 (1981)); increased production of neuron-associated molecules may be measured by bioassay, enzymatic

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5 assay, antibody binding, Northern blot assay, etc., using techniques known in the art and depending on the molecule to be measured; and motor neuron dysfunction may be measured by assessing the physical manifestation of motor neuron disorder, e.g., weakness, motor neuron conduction velocity, or functional disability.

In specific embodiments, motor neuron diseases, disorders, and/or conditions
 10 that may be treated, prevented, and/or diagnosed according to the invention include, but are not limited to, diseases, disorders, and/or conditions such as infarction, infection, exposure to toxin, trauma, surgical damage, degenerative disease or malignancy that may affect motor neurons as well as other components of the nervous system, as well as diseases, disorders, and/or conditions that selectively affect neurons
 15 such as amyotrophic lateral sclerosis, and including, but not limited to, progressive spinal muscular atrophy, progressive bulbar palsy, primary lateral sclerosis, infantile and juvenile muscular atrophy, progressive bulbar paralysis of childhood (Fazio-Londe syndrome), poliomyelitis and the post polio syndrome, and Hereditary Motorsensory Neuropathy (Charcot-Marie-Tooth Disease).

20

Infectious Disease

A polypeptide or polynucleotide and/or agonist or antagonist of the present invention can be used to treat, prevent, and/or diagnose infectious agents. For example, by increasing the immune response, particularly increasing the proliferation
 25 and differentiation of B and/or T cells, infectious diseases may be treated, prevented, and/or diagnosed. The immune response may be increased by either enhancing an existing immune response, or by initiating a new immune response. Alternatively, polypeptide or polynucleotide and/or agonist or antagonist of the present invention may also directly inhibit the infectious agent, without necessarily eliciting an immune
 30 response.

Viruses are one example of an infectious agent that can cause disease or symptoms that can be treated, prevented, and/or diagnosed by a polynucleotide or polypeptide and/or agonist or antagonist of the present invention. Examples of viruses, include, but are not limited to Examples of viruses, include, but are not
 35 limited to the following DNA and RNA viruses and viral families: Arbovirus, Adenoviridae, Arenaviridae, Arterivirus, Birnaviridae, Bunyaviridae, Caliciviridae,

5 Circoviridae, Coronaviridae, Dengue, EBV, HIV, Flaviviridae, Hepadnaviridae
 (Hepatitis), Herpesviridae (such as, Cytomegalovirus, Herpes Simplex, Herpes
 Zoster), Mononegavirus (e.g., Paramyxoviridae, Morbillivirus, Rhabdoviridae),
 Orthomyxoviridae (e.g., Influenza A, Influenza B, and parainfluenza), Papiloma virus,
 Papovaviridae, Parvoviridae, Picornaviridae, Poxviridae (such as Smallpox or
 10 Vaccinia), Reoviridae (e.g., Rotavirus), Retroviridae (HTLV-I, HTLV-II, Lentivirus),
 and Togaviridae (e.g., Rubivirus). Viruses falling within these families can cause a
 variety of diseases or symptoms, including, but not limited to: arthritis, bronchiolitis,
 respiratory syncytial virus, encephalitis, eye infections (e.g., conjunctivitis, keratitis),
 chronic fatigue syndrome, hepatitis (A, B, C, E, Chronic Active, Delta), Japanese B
 15 encephalitis, Junin, Chikungunya, Rift Valley fever, yellow fever, meningitis,
 opportunistic infections (e.g., AIDS), pneumonia, Burkitt's Lymphoma, chickenpox,
 hemorrhagic fever, Measles, Mumps, Parainfluenza, Rabies, the common cold, Polio,
 leukemia, Rubella, sexually transmitted diseases, skin diseases (e.g., Kaposi's, warts),
 and viremia. polynucleotides or polypeptides, or agonists or antagonists of the
 20 invention, can be used to treat, prevent, and/or diagnose any of these symptoms or
 diseases. In specific embodiments, polynucleotides, polypeptides, or agonists or
 antagonists of the invention are used to treat, prevent, and/or diagnose: meningitis,
 Dengue, EBV, and/or hepatitis (e.g., hepatitis B). In an additional specific
 embodiment polynucleotides, polypeptides, or agonists or antagonists of the invention
 25 are used to treat patients nonresponsive to one or more other commercially available
 hepatitis vaccines. In a further specific embodiment polynucleotides, polypeptides, or
 agonists or antagonists of the invention are used to treat, prevent, and/or diagnose
 AIDS.

 Similarly, bacterial or fungal agents that can cause disease or symptoms and
 30 that can be treated, prevented, and/or diagnosed by a polynucleotide or polypeptide
 and/or agonist or antagonist of the present invention include, but not limited to,
 include, but not limited to, the following Gram-Negative and Gram-positive bacteria
 and bacterial families and fungi: Actinomycetales (e.g., Corynebacterium,
 Mycobacterium, Norcardia), Cryptococcus neoformans, Aspergillosis, Bacillaceae
 35 (e.g., Anthrax, Clostridium), Bacteroidaceae, Blastomycosis, Bordetella, Borrelia
 (e.g., Borrelia burgdorferi), Brucellosis, Candidiasis, Campylobacter,

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- 5 Coccidioidomycosis, Cryptococcosis, Dermatocycoses, E. coli (e.g., Enterotoxigenic E. coli and Enterohemorrhagic E. coli), Enterobacteriaceae (Klebsiella, Salmonella (e.g., Salmonella typhi, and Salmonella paratyphi), Serratia, Yersinia), Erysipelothrix, Helicobacter, Legionellosis, Leptospirosis, Listeria, Mycoplasmatales, Mycobacterium leprae, Vibrio cholerae, Neisseriaceae (e.g., Acinetobacter, 10 Gonorrhea, Meningococcal), Meisseria meningitidis, Pasteurellaceae Infections (e.g., Actinobacillus, Haemophilus (e.g., Haemophilus influenza type B), Pasteurella), Pseudomonas, Rickettsiaceae, Chlamydiaceae, Syphilis, Shigella spp., Staphylococcal, Meningococcal, Pneumococcal and Streptococcal (e.g., Streptococcus pneumoniae and Group B Streptococcus). These bacterial or fungal 15 families can cause the following diseases or symptoms, including, but not limited to: bacteremia, endocarditis, eye infections (conjunctivitis, tuberculosis, uveitis), gingivitis, opportunistic infections (e.g., AIDS related infections), paronychia, prosthesis-related infections, Reiter's Disease, respiratory tract infections, such as Whooping Cough or Empyema, sepsis, Lyme Disease, Cat-Scratch Disease, 20 Dysentery, Paratyphoid Fever, food poisoning, Typhoid, pneumonia, Gonorrhea, meningitis (e.g., meningitis types A and B), Chlamydia, Syphilis, Diphtheria, Leprosy, Paratuberculosis, Tuberculosis, Lupus, Botulism, gangrene, tetanus, impetigo, Rheumatic Fever, Scarlet Fever, sexually transmitted diseases, skin diseases (e.g., cellulitis, dermatocycoses), toxemia, urinary tract infections, wound infections. 25 Polynucleotides or polypeptides, agonists or antagonists of the invention, can be used to treat, prevent, and/or diagnose any of these symptoms or diseases. In specific embodiments, polynucleotides, polypeptides, agonists or antagonists of the invention are used to treat, prevent, and/or diagnose: tetanus, Diphtheria, botulism, and/or meningitis type B. 30 Moreover, parasitic agents causing disease or symptoms that can be treated, prevented, and/or diagnosed by a polynucleotide or polypeptide and/or agonist or antagonist of the present invention include, but not limited to, the following families or class: Amebiasis, Babesiosis, Coccidiosis, Cryptosporidiosis, Dientamoebiasis, Dourine, Ectoparasitic, Giardiasis, Helminthiasis, Leishmaniasis, Theileriasis, 35 Toxoplasmosis, Trypanosomiasis, and Trichomonas and Sporozoans (e.g., Plasmodium virax, Plasmodium falciparum, Plasmodium malariae and Plasmodium

5 ovale). These parasites can cause a variety of diseases or symptoms, including, but not limited to: Scabies, Trombiculiasis, eye infections, intestinal disease (e.g., dysentery, giardiasis), liver disease, lung disease, opportunistic infections (e.g., AIDS related), malaria, pregnancy complications, and toxoplasmosis. polynucleotides or polypeptides, or agonists or antagonists of the invention, can be used totreat, prevent, 10 and/or diagnose any of these symptoms or diseases. In specific embodiments, polynucleotides, polypeptides, or agonists or antagonists of the invention are used to treat, prevent, and/or diagnose malaria.

Preferably, treatment or prevention using a polypeptide or polynucleotide and/or agonist or antagonist of the present invention could either be by administering 15 an effective amount of a polypeptide to the patient, or by removing cells from the patient, supplying the cells with a polynucleotide of the present invention, and returning the engineered cells to the patient (ex vivo therapy). Moreover, the polypeptide or polynucleotide of the present invention can be used as an antigen in a vaccine to raise an immune response against infectious disease.

20

Binding Activity

A polypeptide of the present invention may be used to screen for molecules that bind to the polypeptide or for molecules to which the polypeptide binds. The binding of the polypeptide and the molecule may activate (agonist), increase, inhibit 25 (antagonist), or decrease activity of the polypeptide or the molecule bound. Examples of such molecules include antibodies, oligonucleotides, proteins (e.g., receptors), or small molecules.

Preferably, the molecule is closely related to the natural ligand of the polypeptide, e.g., a fragment of the ligand, or a natural substrate, a ligand, a structural 30 or functional mimetic. (See, Coligan et al., Current Protocols in Immunology 1(2):Chapter 5 (1991).) Similarly, the molecule can be closely related to the natural receptor to which the polypeptide binds, or at least, a fragment of the receptor capable of being bound by the polypeptide (e.g., active site). In either case, the molecule can be rationally designed using known techniques.

35 Preferably, the screening for these molecules involves producing appropriate cells which express the polypeptide, either as a secreted protein or on the cell

5 membrane. Preferred cells include cells from mammals, yeast, *Drosophila*, or *E. coli*. Cells expressing the polypeptide (or cell membrane containing the expressed polypeptide) are then preferably contacted with a test compound potentially containing the molecule to observe binding, stimulation, or inhibition of activity of either the polypeptide or the molecule.

10 The assay may simply test binding of a candidate compound to the polypeptide, wherein binding is detected by a label, or in an assay involving competition with a labeled competitor. Further, the assay may test whether the candidate compound results in a signal generated by binding to the polypeptide.

Alternatively, the assay can be carried out using cell-free preparations, 15 polypeptide/molecule affixed to a solid support, chemical libraries, or natural product mixtures. The assay may also simply comprise the steps of mixing a candidate compound with a solution containing a polypeptide, measuring polypeptide/molecule activity or binding, and comparing the polypeptide/molecule activity or binding to a standard.

20 Preferably, an ELISA assay can measure polypeptide level or activity in a sample (e.g., biological sample) using a monoclonal or polyclonal antibody. The antibody can measure polypeptide level or activity by either binding, directly or indirectly, to the polypeptide or by competing with the polypeptide for a substrate.

Additionally, the receptor to which a polypeptide of the invention binds can be 25 identified by numerous methods known to those of skill in the art, for example, ligand panning and FACS sorting (Coligan, et al., *Current Protocols in Immun.*, 1(2), Chapter 5, (1991)). For example, expression cloning is employed wherein polyadenylated RNA is prepared from a cell responsive to the polypeptides, for example, NIH3T3 cells which are known to contain multiple receptors for the FGF 30 family proteins, and SC-3 cells, and a cDNA library created from this RNA is divided into pools and used to transfect COS cells or other cells that are not responsive to the polypeptides. Transfected cells which are grown on glass slides are exposed to the polypeptide of the present invention, after they have been labeled. The polypeptides can be labeled by a variety of means including iodination or inclusion of a recognition 35 site for a site-specific protein kinase.

Following fixation and incubation, the slides are subjected to auto-

5 radiographic analysis. Positive pools are identified and sub-pools are prepared and re-transfected using an iterative sub-pooling and re-screening process, eventually yielding a single clones that encodes the putative receptor.

As an alternative approach for receptor identification, the labeled polypeptides can be photoaffinity linked with cell membrane or extract preparations that express
10 the receptor molecule. Cross-linked material is resolved by PAGE analysis and exposed to X-ray film. The labeled complex containing the receptors of the polypeptides can be excised, resolved into peptide fragments, and subjected to protein microsequencing. The amino acid sequence obtained from microsequencing would be used to design a set of degenerate oligonucleotide probes to screen a cDNA library to
15 identify the genes encoding the putative receptors.

Moreover, the techniques of gene-shuffling, motif-shuffling, exon-shuffling, and/or codon-shuffling (collectively referred to as "DNA shuffling") may be employed to modulate the activities of polypeptides of the invention thereby effectively generating agonists and antagonists of polypeptides of the invention. See
20 generally, U.S. Patent Nos. 5,605,793, 5,811,238, 5,830,721, 5,834,252, and 5,837,458, and Patten, P. A., et al., Curr. Opinion Biotechnol. 8:724-33 (1997); Harayama, S. Trends Biotechnol. 16(2):76-82 (1998); Hansson, L. O., et al., J. Mol. Biol. 287:265-76 (1999); and Lorenzo, M. M. and Blasco, R. Biotechniques 24(2):308-13 (1998) (each of these patents and publications are hereby incorporated
25 by reference). In one embodiment, alteration of polynucleotides and corresponding polypeptides of the invention may be achieved by DNA shuffling. DNA shuffling involves the assembly of two or more DNA segments into a desired polynucleotide sequence of the invention molecule by homologous, or site-specific, recombination. In another embodiment, polynucleotides and corresponding polypeptides of the
30 invention may be altered by being subjected to random mutagenesis by error-prone PCR, random nucleotide insertion or other methods prior to recombination. In another embodiment, one or more components, motifs, sections, parts, domains, fragments, etc., of the polypeptides of the invention may be recombined with one or more components, motifs, sections, parts, domains, fragments, etc. of one or more
35 heterologous molecules. In preferred embodiments, the heterologous molecules are family members. In further preferred embodiments, the heterologous molecule is a

5 growth factor such as, for example, platelet-derived growth factor (PDGF), insulin-like growth factor (IGF-I), transforming growth factor (TGF)-alpha, epidermal growth factor (EGF), fibroblast growth factor (FGF), TGF-beta, bone morphogenetic protein (BMP)-2, BMP-4, BMP-5, BMP-6, BMP-7, activins A and B, decapentaplegic(dpp), 60A, OP-2, dorsalin, growth differentiation factors (GDFs), nodal, MIS, inhibin-
10 alpha, TGF-beta1, TGF-beta2, TGF-beta3, TGF-beta5, and glial-derived neurotrophic factor (GDNF).

Other preferred fragments are biologically active fragments of the polypeptides of the invention. Biologically active fragments are those exhibiting activity similar, but not necessarily identical, to an activity of the polypeptide. The
15 biological activity of the fragments may include an improved desired activity, or a decreased undesirable activity.

Additionally, this invention provides a method of screening compounds to identify those which modulate the action of the polypeptide of the present invention. An example of such an assay comprises combining a mammalian fibroblast cell, a the
20 polypeptide of the present invention, the compound to be screened and 3[H] thymidine under cell culture conditions where the fibroblast cell would normally proliferate. A control assay may be performed in the absence of the compound to be screened and compared to the amount of fibroblast proliferation in the presence of the compound to determine if the compound stimulates proliferation by determining the
25 uptake of 3[H] thymidine in each case. The amount of fibroblast cell proliferation is measured by liquid scintillation chromatography which measures the incorporation of 3[H] thymidine. Both agonist and antagonist compounds may be identified by this procedure.

In another method, a mammalian cell or membrane preparation expressing a
30 receptor for a polypeptide of the present invention is incubated with a labeled polypeptide of the present invention in the presence of the compound. The ability of the compound to enhance or block this interaction could then be measured. Alternatively, the response of a known second messenger system following interaction of a compound to be screened and the receptor is measured and the ability
35 of the compound to bind to the receptor and elicit a second messenger response is measured to determine if the compound is a potential agonist or antagonist. Such

5 second messenger systems include but are not limited to, cAMP guanylate cyclase, ion channels or phosphoinositide hydrolysis.

All of these above assays can be used as diagnostic or prognostic markers. The molecules discovered using these assays can be used to treat, prevent, and/or diagnose disease or to bring about a particular result in a patient (e.g., blood vessel growth) by
10 activating or inhibiting the polypeptide/molecule. Moreover, the assays can discover agents which may inhibit or enhance the production of the polypeptides of the invention from suitably manipulated cells or tissues. Therefore, the invention includes a method of identifying compounds which bind to the polypeptides of the invention comprising the steps of: (a) incubating a candidate binding compound with the
15 polypeptide; and (b) determining if binding has occurred. Moreover, the invention includes a method of identifying agonists/antagonists comprising the steps of: (a) incubating a candidate compound with the polypeptide, (b) assaying a biological activity, and (b) determining if a biological activity of the polypeptide has been altered.

20 Also, one could identify molecules bind a polypeptide of the invention experimentally by using the beta-pleated sheet regions contained in the polypeptide sequence of the protein. Accordingly, specific embodiments of the invention are directed to polynucleotides encoding polypeptides which comprise, or alternatively consist of, the amino acid sequence of each beta pleated sheet regions in a disclosed
25 polypeptide sequence. Additional embodiments of the invention are directed to polynucleotides encoding polypeptides which comprise, or alternatively consist of, any combination or all of contained in the polypeptide sequences of the invention. Additional preferred embodiments of the invention are directed to polypeptides which comprise, or alternatively consist of, the amino acid sequence of each of the beta
30 pleated sheet regions in one of the polypeptide sequences of the invention. Additional embodiments of the invention are directed to polypeptides which comprise, or alternatively consist of, any combination or all of the beta pleated sheet regions in one of the polypeptide sequences of the invention.

35 **Targeted Delivery**

In another embodiment, the invention provides a method of delivering

5 compositions to targeted cells expressing a receptor for a polypeptide of the invention, or cells expressing a cell bound form of a polypeptide of the invention.

As discussed herein, polypeptides or antibodies of the invention may be associated with heterologous polypeptides, heterologous nucleic acids, toxins, or prodrugs via hydrophobic, hydrophilic, ionic and/or covalent interactions. In one
10 embodiment, the invention provides a method for the specific delivery of compositions of the invention to cells by administering polypeptides of the invention (including antibodies) that are associated with heterologous polypeptides or nucleic acids. In one example, the invention provides a method for delivering a therapeutic protein into the targeted cell. In another example, the invention provides a method for
15 delivering a single stranded nucleic acid (e.g., antisense or ribozymes) or double stranded nucleic acid (e.g., DNA that can integrate into the cell's genome or replicate episomally and that can be transcribed) into the targeted cell.

In another embodiment, the invention provides a method for the specific destruction of cells (e.g., the destruction of tumor cells) by administering polypeptides
20 of the invention (e.g., polypeptides of the invention or antibodies of the invention) in association with toxins or cytotoxic prodrugs.

By "toxin" is meant compounds that bind and activate endogenous cytotoxic effector systems, radioisotopes, holotoxins, modified toxins, catalytic subunits of toxins, or any molecules or enzymes not normally present in or on the surface of a cell
25 that under defined conditions cause the cell's death. Toxins that may be used according to the methods of the invention include, but are not limited to, radioisotopes known in the art, compounds such as, for example, antibodies (or complement fixing containing portions thereof) that bind an inherent or induced endogenous cytotoxic effector system, thymidine kinase, endonuclease, RNase, alpha toxin, ricin, abrin,
30 Pseudomonas exotoxin A, diphtheria toxin, saporin, momordin, gelonin, pokeweed antiviral protein, alpha-sarcin and cholera toxin. By "cytotoxic prodrug" is meant a non-toxic compound that is converted by an enzyme, normally present in the cell, into a cytotoxic compound. Cytotoxic prodrugs that may be used according to the methods of the invention include, but are not limited to, glutamyl derivatives of benzoic acid
35 mustard alkylating agent, phosphate derivatives of etoposide or mitomycin C, cytosine arabinoside, daunorubisin, and phenoxyacetamide derivatives of

5 doxorubicin.

Drug Screening

Further contemplated is the use of the polypeptides of the present invention, or the polynucleotides encoding these polypeptides, to screen for molecules which
10 modify the activities of the polypeptides of the present invention. Such a method would include contacting the polypeptide of the present invention with a selected compound(s) suspected of having antagonist or agonist activity, and assaying the activity of these polypeptides following binding.

This invention is particularly useful for screening therapeutic compounds by
15 using the polypeptides of the present invention, or binding fragments thereof, in any of a variety of drug screening techniques. The polypeptide or fragment employed in such a test may be affixed to a solid support, expressed on a cell surface, free in solution, or located intracellularly. One method of drug screening utilizes eukaryotic or prokaryotic host cells which are stably transformed with recombinant nucleic acids
20 expressing the polypeptide or fragment. Drugs are screened against such transformed cells in competitive binding assays. One may measure, for example, the formulation of complexes between the agent being tested and a polypeptide of the present invention.

Thus, the present invention provides methods of screening for drugs or any
25 other agents which affect activities mediated by the polypeptides of the present invention. These methods comprise contacting such an agent with a polypeptide of the present invention or a fragment thereof and assaying for the presence of a complex between the agent and the polypeptide or a fragment thereof, by methods well known in the art. In such a competitive binding assay, the agents to screen are typically
30 labeled. Following incubation, free agent is separated from that present in bound form, and the amount of free or uncomplexed label is a measure of the ability of a particular agent to bind to the polypeptides of the present invention.

Another technique for drug screening provides high throughput screening for compounds having suitable binding affinity to the polypeptides of the present
35 invention, and is described in great detail in European Patent Application 84/03564, published on September 13, 1984, which is incorporated herein by reference herein.

5 Briefly stated, large numbers of different small peptide test compounds are synthesized on a solid substrate, such as plastic pins or some other surface. The peptide test compounds are reacted with polypeptides of the present invention and washed. Bound polypeptides are then detected by methods well known in the art. Purified polypeptides are coated directly onto plates for use in the aforementioned
10 drug screening techniques. In addition, non-neutralizing antibodies may be used to capture the peptide and immobilize it on the solid support.

This invention also contemplates the use of competitive drug screening assays in which neutralizing antibodies capable of binding polypeptides of the present invention specifically compete with a test compound for binding to the polypeptides
15 or fragments thereof. In this manner, the antibodies are used to detect the presence of any peptide which shares one or more antigenic epitopes with a polypeptide of the invention.

The human K+betaM4 or K+betaM5 polypeptides and/or peptides of the present invention, or immunogenic fragments or oligopeptides thereof, can be used for
20 screening therapeutic drugs or compounds in a variety of drug screening techniques. The fragment employed in such a screening assay may be free in solution, affixed to a solid support, borne on a cell surface, or located intracellularly. The reduction or abolition of activity of the formation of binding complexes between the ion channel protein and the agent being tested can be measured. Thus, the present invention
25 provides a method for screening or assessing a plurality of compounds for their specific binding affinity with a K+betaM4 or K+betaM5 polypeptide, or a bindable peptide fragment, of this invention, comprising providing a plurality of compounds, combining the K+betaM4 or K+betaM5 polypeptide, or a bindable peptide fragment, with each of a plurality of compounds for a time sufficient to allow binding under
30 suitable conditions and detecting binding of the K+betaM4 or K+betaM5 polypeptide or peptide to each of the plurality of test compounds, thereby identifying the compounds that specifically bind to the K+betaM4 or K+betaM5 polypeptide or peptide.

Methods of identifying compounds that modulate the activity of the novel
35 human K+betaM4 or K+betaM5 polypeptides and/or peptides are provided by the present invention and comprise combining a potential or candidate compound or drug

5 modulator of potassium channel beta subunit biological activity with an K+betaM4 or K+betaM5 polypeptide or peptide, for example, the K+betaM4 or K+betaM5 amino acid sequence as set forth in SEQ ID NO:2, or SEQ ID NO:24, and measuring an effect of the candidate compound or drug modulator on the biological activity of the K+betaM4 or K+betaM5 polypeptide or peptide. Such measurable effects include, for
10 example, physical binding interaction; the ability to cleave a suitable potassium channel beta subunit substrate; effects on native and cloned K+betaM4 or K+betaM5-expressing cell line; and effects of modulators or other potassium channel beta subunit-mediated physiological measures.

Another method of identifying compounds that modulate the biological
15 activity of the novel K+betaM4 or K+betaM5 polypeptides of the present invention comprises combining a potential or candidate compound or drug modulator of a potassium channel beta subunit biological activity with a host cell that expresses the K+betaM4 or K+betaM5 polypeptide and measuring an effect of the candidate compound or drug modulator on the biological activity of the K+betaM4 or
20 K+betaM5 polypeptide. The host cell can also be capable of being induced to express the K+betaM4 or K+betaM5 polypeptide, e.g., via inducible expression. Physiological effects of a given modulator candidate on the K+betaM4 or K+betaM5 polypeptide can also be measured. Thus, cellular assays for particular potassium channel beta subunit modulators may be either direct measurement or quantification of the physical
25 biological activity of the K+betaM4 or K+betaM5 polypeptide, or they may be measurement or quantification of a physiological effect. Such methods preferably employ a K+betaM4 or K+betaM5 polypeptide as described herein, or an overexpressed recombinant K+betaM4 or K+betaM5 polypeptide in suitable host cells containing an expression vector as described herein, wherein the K+betaM4 or
30 K+betaM5 polypeptide is expressed, overexpressed, or undergoes upregulated expression.

Another aspect of the present invention embraces a method of screening for a compound that is capable of modulating the biological activity of a K+betaM4 or K+betaM5 polypeptide, comprising providing a host cell containing an expression
35 vector harboring a nucleic acid sequence encoding a K+betaM4 or K+betaM5 polypeptide, or a functional peptide or portion thereof (e.g., SEQ ID NOS:2);

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5 determining the biological activity of the expressed K+betaM4 or K+betaM5 polypeptide in the absence of a modulator compound; contacting the cell with the modulator compound and determining the biological activity of the expressed K+betaM4 or K+betaM5 polypeptide in the presence of the modulator compound. In such a method, a difference between the activity of the K+betaM4 or K+betaM5
10 polypeptide in the presence of the modulator compound and in the absence of the modulator compound indicates a modulating effect of the compound.

Essentially any chemical compound can be employed as a potential modulator or ligand in the assays according to the present invention. Compounds tested as potassium channel beta subunit modulators can be any small chemical compound, or
15 biological entity (e.g., protein, sugar, nucleic acid, lipid). Test compounds will typically be small chemical molecules and peptides. Generally, the compounds used as potential modulators can be dissolved in aqueous or organic (e.g., DMSO-based) solutions. The assays are designed to screen large chemical libraries by automating the assay steps and providing compounds from any convenient source. Assays are
20 typically run in parallel, for example, in microtiter formats on microtiter plates in robotic assays. There are many suppliers of chemical compounds, including Sigma (St. Louis, MO), Aldrich (St. Louis, MO), Sigma-Aldrich (St. Louis, MO), Fluka Chemika-Biochemika Analytika (Buchs, Switzerland), for example. Also, compounds may be synthesized by methods known in the art.

25 High throughput screening methodologies are particularly envisioned for the detection of modulators of the novel K+betaM4 or K+betaM5 polynucleotides and polypeptides described herein. Such high throughput screening methods typically involve providing a combinatorial chemical or peptide library containing a large number of potential therapeutic compounds (e.g., ligand or modulator compounds).
30 Such combinatorial chemical libraries or ligand libraries are then screened in one or more assays to identify those library members (e.g., particular chemical species or subclasses) that display a desired characteristic activity. The compounds so identified can serve as conventional lead compounds, or can themselves be used as potential or actual therapeutics.

35 A combinatorial chemical library is a collection of diverse chemical compounds generated either by chemical synthesis or biological synthesis, by

5 combining a number of chemical building blocks (i.e., reagents such as amino acids). As an example, a linear combinatorial library, e.g., a polypeptide or peptide library, is formed by combining a set of chemical building blocks in every possible way for a given compound length (i.e., the number of amino acids in a polypeptide or peptide compound). Millions of chemical compounds can be synthesized through such
10 combinatorial mixing of chemical building blocks.

The preparation and screening of combinatorial chemical libraries is well known to those having skill in the pertinent art. Combinatorial libraries include, without limitation, peptide libraries (e.g. U.S. Patent No. 5,010,175; Furka, 1991, *Int. J. Pept. Prot. Res.*, 37:487-493; and Houghton et al., 1991, *Nature*, 354:84-88). Other
15 chemistries for generating chemical diversity libraries can also be used. Nonlimiting examples of chemical diversity library chemistries include, peptides (PCT Publication No. WO 91/019735), encoded peptides (PCT Publication No. WO 93/20242), random bio-oligomers (PCT Publication No. WO 92/00091), benzodiazepines (U.S. Patent No. 5,288,514), diversomers such as hydantoins, benzodiazepines and dipeptides
20 (Hobbs et al., 1993, *Proc. Natl. Acad. Sci. USA*, 90:6909-6913), vinylogous polypeptides (Hagihara et al., 1992, *J. Amer. Chem. Soc.*, 114:6568), nonpeptidal peptidomimetics with glucose scaffolding (Hirschmann et al., 1992, *J. Amer. Chem. Soc.*, 114:9217-9218), analogous organic synthesis of small compound libraries (Chen et al., 1994, *J. Amer. Chem. Soc.*, 116:2661), oligocarbamates (Cho et al., 1993,
25 *Science*, 261:1303), and/or peptidyl phosphonates (Campbell et al., 1994, *J. Org. Chem.*, 59:658), nucleic acid libraries (see Ausubel, Berger and Sambrook, all supra), peptide nucleic acid libraries (U.S. Patent No. 5,539,083), antibody libraries (e.g., Vaughn et al., 1996, *Nature Biotechnology*, 14(3):309-314) and PCT/US96/10287), carbohydrate libraries (e.g., Liang et al., 1996, *Science*, 274:1520-1522) and U.S.
30 Patent No. 5,593,853), small organic molecule libraries (e.g., benzodiazepines, Baum C&EN, Jan. 18, 1993, page 33; and U.S. Patent No. 5,288,514; isoprenoids, U.S. Patent No. 5,569,588; thiazolidinones and metathiazanones, U.S. Patent No. 5,549,974; pyrrolidines, U.S. Patent Nos. 5,525,735 and 5,519,134; morpholino compounds, U.S. Patent No. 5,506,337; and the like).

35 Devices for the preparation of combinatorial libraries are commercially available (e.g., 357 MPS, 390 MPS, Advanced Chem Tech, Louisville KY;

5 Symphony, Rainin, Woburn, MA; 433A Applied Biosystems, Foster City, CA; 9050 Plus, Millipore, Bedford, MA). In addition, a large number of combinatorial libraries are commercially available (e.g., ComGenex, Princeton, NJ; Asinex, Moscow, Russia; Tripos, Inc., St. Louis, MO; ChemStar, Ltd., Moscow, Russia; 3D Pharmaceuticals, Exton, PA; Martek Biosciences, Columbia, MD, and the like).

10 In one embodiment, the invention provides solid phase based *in vitro* assays in a high throughput format, where the cell or tissue expressing an ion channel is attached to a solid phase substrate. In such high throughput assays, it is possible to screen up to several thousand different modulators or ligands in a single day. In particular, each well of a microtiter plate can be used to perform a separate assay
15 against a selected potential modulator, or, if concentration or incubation time effects are to be observed, every 5-10 wells can test a single modulator. Thus, a single standard microtiter plate can assay about 96 modulators. If 1536 well plates are used, then a single plate can easily assay from about 100 to about 1500 different compounds. It is possible to assay several different plates per day; thus, for example,
20 assay screens for up to about 6,000-20,000 different compounds are possible using the described integrated systems.

In another of its aspects, the present invention encompasses screening and small molecule (e.g., drug) detection assays which involve the detection or identification of small molecules that can bind to a given protein, i.e., a K+betaM4 or
25 K+betaM5 polypeptide or peptide. Particularly preferred are assays suitable for high throughput screening methodologies.

In such binding-based detection, identification, or screening assays, a functional assay is not typically required. All that is needed is a target protein, preferably substantially purified, and a library or panel of compounds (e.g., ligands,
30 drugs, small molecules) or biological entities to be screened or assayed for binding to the protein target. Preferably, most small molecules that bind to the target protein will modulate activity in some manner, due to preferential, higher affinity binding to functional areas or sites on the protein.

An example of such an assay is the fluorescence based thermal shift assay (3-
35 Dimensional Pharmaceuticals, Inc., 3DP, Exton, PA) as described in U.S. Patent Nos. 6,020,141 and 6,036,920 to Pantoliano et al.; see also, J. Zimmerman, 2000, *Gen.*

5 *Eng. News*, 20(8)). The assay allows the detection of small molecules (e.g., drugs, ligands) that bind to expressed, and preferably purified, ion channel polypeptide based on affinity of binding determinations by analyzing thermal unfolding curves of protein-drug or ligand complexes. The drugs or binding molecules determined by this technique can be further assayed, if desired, by methods, such as those described
10 herein, to determine if the molecules affect or modulate function or activity of the target protein.

To purify a K+betaM4 or K+betaM5 polypeptide or peptide to measure a biological binding or ligand binding activity, the source may be a whole cell lysate that can be prepared by successive freeze-thaw cycles (e.g., one to three) in the
15 presence of standard protease inhibitors. The K+betaM4 or K+betaM5 polypeptide may be partially or completely purified by standard protein purification methods, e.g., affinity chromatography using specific antibody described *infra*, or by ligands specific for an epitope tag engineered into the recombinant K+betaM4 or K+betaM5 polypeptide molecule, also as described herein. Binding activity can then be measured
20 as described.

Compounds which are identified according to the methods provided herein, and which modulate or regulate the biological activity or physiology of the K+betaM4 or K+betaM5 polypeptides according to the present invention are a preferred embodiment of this invention. It is contemplated that such modulatory compounds
25 may be employed in treatment and therapeutic methods for treating a condition that is mediated by the novel K+betaM4 or K+betaM5 polypeptides by administering to an individual in need of such treatment a therapeutically effective amount of the compound identified by the methods described herein.

In addition, the present invention provides methods for treating an individual
30 in need of such treatment for a disease, disorder, or condition that is mediated by the K+betaM4 or K+betaM5 polypeptides of the invention, comprising administering to the individual a therapeutically effective amount of the K+betaM4 or K+betaM5-modulating compound identified by a method provided herein.

35 **Antisense And Ribozyme (Antagonists)**

In specific embodiments, antagonists according to the present invention are

5 nucleic acids corresponding to the sequences contained in SEQ ID NO:1, or SEQ ID NO:23, or the complementary strand thereof, and/or to nucleotide sequences contained a deposited clone. In one embodiment, antisense sequence is generated internally by the organism, in another embodiment, the antisense sequence is separately administered (see, for example, O'Connor, *Neurochem.*, 56:560 (1991)).

10 Oligodeoxynucleotides as Antisense Inhibitors of Gene Expression, CRC Press, Boca Raton, FL (1988). Antisense technology can be used to control gene expression through antisense DNA or RNA, or through triple-helix formation. Antisense techniques are discussed for example, in Okano, *Neurochem.*, 56:560 (1991); Oligodeoxynucleotides as Antisense Inhibitors of Gene Expression, CRC Press, Boca

15 Raton, FL (1988). Triple helix formation is discussed in, for instance, Lee et al., *Nucleic Acids Research*, 6:3073 (1979); Cooney et al., *Science*, 241:456 (1988); and Dervan et al., *Science*, 251:1300 (1991). The methods are based on binding of a polynucleotide to a complementary DNA or RNA.

For example, the use of c-myc and c-myb antisense RNA constructs to inhibit

20 the growth of the non-lymphocytic leukemia cell line HL-60 and other cell lines was previously described. (Wickstrom et al. (1988); Anfossi et al. (1989)). These experiments were performed in vitro by incubating cells with the oligoribonucleotide. A similar procedure for in vivo use is described in WO 91/15580. Briefly, a pair of oligonucleotides for a given antisense RNA is produced as follows: A sequence

25 complimentary to the first 15 bases of the open reading frame is flanked by an EcoRI site on the 5 end and a HindIII site on the 3 end. Next, the pair of oligonucleotides is heated at 90°C for one minute and then annealed in 2X ligation buffer (20mM TRIS HCl pH 7.5, 10mM MgCl₂, 10mM dithiothreitol (DTT) and 0.2 mM ATP) and then ligated to the EcoRI/Hind III site of the retroviral vector PMV7 (WO 91/15580).

30 For example, the 5' coding portion of a polynucleotide that encodes the mature polypeptide of the present invention may be used to design an antisense RNA oligonucleotide of from about 10 to 40 base pairs in length. A DNA oligonucleotide is designed to be complementary to a region of the gene involved in transcription thereby preventing transcription and the production of the receptor. The antisense

35 RNA oligonucleotide hybridizes to the mRNA in vivo and blocks translation of the mRNA molecule into receptor polypeptide.

5 In one embodiment, the antisense nucleic acid of the invention is produced intracellularly by transcription from an exogenous sequence. For example, a vector or a portion thereof, is transcribed, producing an antisense nucleic acid (RNA) of the invention. Such a vector would contain a sequence encoding the antisense nucleic acid of the invention. Such a vector can remain episomal or become chromosomally
10 integrated, as long as it can be transcribed to produce the desired antisense RNA. Such vectors can be constructed by recombinant DNA technology methods standard in the art. Vectors can be plasmid, viral, or others known in the art, used for replication and expression in vertebrate cells. Expression of the sequence encoding a polypeptide of the invention, or fragments thereof, can be by any promoter known in
15 the art to act in vertebrate, preferably human cells. Such promoters can be inducible or constitutive. Such promoters include, but are not limited to, the SV40 early promoter region (Bernoist and Chambon, Nature, 29:304-310 (1981), the promoter contained in the 3' long terminal repeat of Rous sarcoma virus (Yamamoto et al., Cell, 22:787-797 (1980), the herpes thymidine promoter (Wagner et al., Proc. Natl. Acad. Sci. U.S.A.,
20 78:1441-1445 (1981), the regulatory sequences of the metallothionein gene (Brinster et al., Nature, 296:39-42 (1982)), etc.

 The antisense nucleic acids of the invention comprise a sequence complementary to at least a portion of an RNA transcript of a gene of interest. However, absolute complementarity, although preferred, is not required. A sequence
25 "complementary to at least a portion of an RNA," referred to herein, means a sequence having sufficient complementarity to be able to hybridize with the RNA, forming a stable duplex; in the case of double stranded antisense nucleic acids of the invention, a single strand of the duplex DNA may thus be tested, or triplex formation may be assayed. The ability to hybridize will depend on both the degree of
30 complementarity and the length of the antisense nucleic acid. Generally, the larger the hybridizing nucleic acid, the more base mismatches with a RNA sequence of the invention it may contain and still form a stable duplex (or triplex as the case may be). One skilled in the art can ascertain a tolerable degree of mismatch by use of standard procedures to determine the melting point of the hybridized complex.

35 Oligonucleotides that are complementary to the 5' end of the message, e.g., the 5' untranslated sequence up to and including the AUG initiation codon, should

5 work most efficiently at inhibiting translation. However, sequences complementary to the 3' untranslated sequences of mRNAs have been shown to be effective at inhibiting translation of mRNAs as well. See generally, Wagner, R., *Nature*, 372:333-335 (1994). Thus, oligonucleotides complementary to either the 5' - or 3' - non-translated, non-coding regions of a polynucleotide sequence of the invention could be
10 used in an antisense approach to inhibit translation of endogenous mRNA. Oligonucleotides complementary to the 5' untranslated region of the mRNA should include the complement of the AUG start codon. Antisense oligonucleotides complementary to mRNA coding regions are less efficient inhibitors of translation but could be used in accordance with the invention. Whether designed to hybridize to the
15 5' -, 3' - or coding region of mRNA, antisense nucleic acids should be at least six nucleotides in length, and are preferably oligonucleotides ranging from 6 to about 50 nucleotides in length. In specific aspects the oligonucleotide is at least 10 nucleotides, at least 17 nucleotides, at least 25 nucleotides or at least 50 nucleotides.

The polynucleotides of the invention can be DNA or RNA or chimeric
20 mixtures or derivatives or modified versions thereof, single-stranded or double-stranded. The oligonucleotide can be modified at the base moiety, sugar moiety, or phosphate backbone, for example, to improve stability of the molecule, hybridization, etc. The oligonucleotide may include other appended groups such as peptides (e.g., for targeting host cell receptors in vivo), or agents facilitating transport across the cell
25 membrane (see, e.g., Letsinger et al., *Proc. Natl. Acad. Sci. U.S.A.* 86:6553-6556 (1989); Lemaitre et al., *Proc. Natl. Acad. Sci.*, 84:648-652 (1987); PCT Publication NO: WO88/09810, published December 15, 1988) or the blood-brain barrier (see, e.g., PCT Publication NO: WO89/10134, published April 25, 1988), hybridization-triggered cleavage agents. (See, e.g., Krol et al., *BioTechniques*, 6:958-976 (1988)) or
30 intercalating agents. (See, e.g., Zon, *Pharm. Res.*, 5:539-549 (1988)). To this end, the oligonucleotide may be conjugated to another molecule, e.g., a peptide, hybridization triggered cross-linking agent, transport agent, hybridization-triggered cleavage agent, etc.

The antisense oligonucleotide may comprise at least one modified base moiety
35 which is selected from the group including, but not limited to, 5-fluorouracil, 5-bromouracil, 5-chlorouracil, 5-iodouracil, hypoxanthine, xanthine, 4-acetylcytosine,

5 5-(carboxyhydroxymethyl) uracil, 5-carboxymethylaminomethyl-2-thiouridine, 5-carboxymethylaminomethyluracil, dihydrouracil, beta-D-galactosylqueosine, inosine, N6-isopentenyladenine, 1-methylguanine, 1-methylinosine, 2,2-dimethylguanine, 2-methyladenine, 2-methylguanine, 3-methylcytosine, 5-methylcytosine, N6-adenine, 7-methylguanine, 5-methylaminomethyluracil, 5-methoxyaminomethyl-2-thiouracil,
 10 beta-D-mannosylqucosine, 5'-methoxycarboxymethyluracil, 5-methoxyuracil, 2-methylthio-N6-isopentenyladenine, uracil-5-oxyacetic acid (v), wybutoxosine, pseudouracil, queosine, 2-thiocytosine, 5-methyl-2-thiouracil, 2-thiouracil, 4-thiouracil, 5-methyluracil, uracil-5-oxyacetic acid methylester, uracil-5-oxyacetic acid (v), 5-methyl-2-thiouracil, 3-(3-amino-3-N-2-carboxypropyl) uracil, (acp3)w, and 2,6-
 15 diaminopurine.

The antisense oligonucleotide may also comprise at least one modified sugar moiety selected from the group including, but not limited to, arabinose, 2-fluoroarabinose, xylulose, and hexose.

In yet another embodiment, the antisense oligonucleotide comprises at least
 20 one modified phosphate backbone selected from the group including, but not limited to, a phosphorothioate, a phosphorodithioate, a phosphoramidothioate, a phosphoramidate, a phosphordiamidate, a methylphosphonate, an alkyl phosphotriester, and a formacetal or analog thereof.

In yet another embodiment, the antisense oligonucleotide is an a-anomeric
 25 oligonucleotide. An a-anomeric oligonucleotide forms specific double-stranded hybrids with complementary RNA in which, contrary to the usual b-units, the strands run parallel to each other (Gautier et al., Nucl. Acids Res., 15:6625-6641 (1987)). The oligonucleotide is a 2'-O-methylribonucleotide (Inoue et al., Nucl. Acids Res., 15:6131-6148 (1987)), or a chimeric RNA-DNA analogue (Inoue et al., FEBS Lett.
 30 215:327-330 (1987)).

Polynucleotides of the invention may be synthesized by standard methods known in the art, e.g. by use of an automated DNA synthesizer (such as are commercially available from Biosearch, Applied Biosystems, etc.). As examples, phosphorothioate oligonucleotides may be synthesized by the method of Stein et al.
 35 (Nucl. Acids Res., 16:3209 (1988)), methylphosphonate oligonucleotides can be prepared by use of controlled pore glass polymer supports (Sarin et al., Proc. Natl.

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5 Acad. Sci. U.S.A., 85:7448-7451 (1988)), etc.

While antisense nucleotides complementary to the coding region sequence of the invention could be used, those complementary to the transcribed untranslated region are most preferred.

Potential antagonists according to the invention also include catalytic RNA, or
 10 a ribozyme (See, e.g., PCT International Publication WO 90/11364, published October 4, 1990; Sarver et al, Science, 247:1222-1225 (1990). While ribozymes that cleave mRNA at site specific recognition sequences can be used to destroy mRNAs corresponding to the polynucleotides of the invention, the use of hammerhead ribozymes is preferred. Hammerhead ribozymes cleave mRNAs at locations dictated
 15 by flanking regions that form complementary base pairs with the target mRNA. The sole requirement is that the target mRNA have the following sequence of two bases: 5' -UG-3'. The construction and production of hammerhead ribozymes is well known in the art and is described more fully in Haseloff and Gerlach, Nature, 334:585-591 (1988). There are numerous potential hammerhead ribozyme cleavage sites within
 20 each nucleotide sequence disclosed in the sequence listing. Preferably, the ribozyme is engineered so that the cleavage recognition site is located near the 5' end of the mRNA corresponding to the polynucleotides of the invention; i.e., to increase efficiency and minimize the intracellular accumulation of non-functional mRNA transcripts.

25 As in the antisense approach, the ribozymes of the invention can be composed of modified oligonucleotides (e.g. for improved stability, targeting, etc.) and should be delivered to cells which express the polynucleotides of the invention in vivo. DNA constructs encoding the ribozyme may be introduced into the cell in the same manner as described above for the introduction of antisense encoding DNA. A preferred
 30 method of delivery involves using a DNA construct "encoding" the ribozyme under the control of a strong constitutive promoter, such as, for example, pol III or pol II promoter, so that transfected cells will produce sufficient quantities of the ribozyme to destroy endogenous messages and inhibit translation. Since ribozymes unlike antisense molecules, are catalytic, a lower intracellular concentration is required for
 35 efficiency.

Antagonist/agonist compounds may be employed to inhibit the cell growth and

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5 proliferation effects of the polypeptides of the present invention on neoplastic cells and tissues, i.e. stimulation of angiogenesis of tumors, and, therefore, retard or prevent abnormal cellular growth and proliferation, for example, in tumor formation or growth.

The antagonist/agonist may also be employed to prevent hyper-vascular
 10 diseases, and prevent the proliferation of epithelial lens cells after extracapsular cataract surgery. Prevention of the mitogenic activity of the polypeptides of the present invention may also be desirable in cases such as restenosis after balloon angioplasty.

The antagonist/agonist may also be employed to prevent the growth of scar
 15 tissue during wound healing.

The antagonist/agonist may also be employed to treat, prevent, and/or diagnose the diseases described herein.

Thus, the invention provides a method of treating or preventing diseases, disorders, and/or conditions, including but not limited to the diseases, disorders,
 20 and/or conditions listed throughout this application, associated with overexpression of a polynucleotide of the present invention by administering to a patient (a) an antisense molecule directed to the polynucleotide of the present invention, and/or (b) a ribozyme directed to the polynucleotide of the present invention.

invention, and/or (b) a ribozyme directed to the polynucleotide of the present
 25 invention.

Biotic Associations

A polynucleotide or polypeptide and/or agonist or antagonist of the present invention may increase the organisms ability, either directly or indirectly, to initiate
 30 and/or maintain biotic associations with other organisms. Such associations may be symbiotic, nonsymbiotic, endosymbiotic, macrosymbiotic, and/or microsymbiotic in nature. In general, a polynucleotide or polypeptide and/or agonist or antagonist of the present invention may increase the organisms ability to form biotic associations with any member of the fungal, bacterial, lichen, mycorrhizal, cyanobacterial,
 35 dinoflagellate, and/or algal, kingdom, phylums, families, classes, genuses, and/or species.

5 The mechanism by which a polynucleotide or polypeptide and/or agonist or
 antagonist of the present invention may increase the host organisms ability, either
 directly or indirectly, to initiate and/or maintain biotic associations is variable, though
 may include, modulating osmolarity to desirable levels for the symbiont, modulating
 pH to desirable levels for the symbiont, modulating secretions of organic acids,
 10 modulating the secretion of specific proteins, phenolic compounds, nutrients, or the
 increased expression of a protein required for host-biotic organisms interactions (e.g.,
 a receptor, ligand, etc.). Additional mechanisms are known in the art and are
 encompassed by the invention (see, for example, “Microbial Signalling and
 Communication”, eds., R. England, G. Hobbs, N. Bainton, and D. McL. Roberts,
 15 Cambridge University Press, Cambridge, (1999); which is hereby incorporated herein
 by reference).

In an alternative embodiment, a polynucleotide or polypeptide and/or agonist
 or antagonist of the present invention may decrease the host organisms ability to form
 biotic associations with another organism, either directly or indirectly. The
 20 mechanism by which a polynucleotide or polypeptide and/or agonist or antagonist of
 the present invention may decrease the host organisms ability, either directly or
 indirectly, to initiate and/or maintain biotic associations with another organism is
 variable, though may include, modulating osmolarity to undesirable levels,
 modulating pH to undesirable levels, modulating secretions of organic acids,
 25 modulating the secretion of specific proteins, phenolic compounds, nutrients, or the
 decreased expression of a protein required for host-biotic organisms interactions (e.g.,
 a receptor, ligand, etc.). Additional mechanisms are known in the art and are
 encompassed by the invention (see, for example, “Microbial Signalling and
 Communication”, eds., R. England, G. Hobbs, N. Bainton, and D. McL. Roberts,
 30 Cambridge University Press, Cambridge, (1999); which is hereby incorporated herein
 by reference).

The hosts ability to maintain biotic associations with a particular pathogen has
 significant implications for the overall health and fitness of the host. For example,
 human hosts have symbiosis with enteric bacteria in their gastrointestinal tracts,
 35 particularly in the small and large intestine. In fact, bacteria counts in feces of the
 distal colon often approach 10^{12} per milliliter of feces. Examples of bowel flora in the

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5 gastrointestinal tract are members of the Enterobacteriaceae, Bacteriodes, in addition to a-hemolytic streptococci, E. coli, Bifobacteria, Anaerobic cocci, Eubacteria, Costridia, lactobacilli, and yeasts. Such bacteria, among other things, assist the host in the assimilation of nutrients by breaking down food stuffs not typically broken down by the hosts digestive system, particularly in the hosts bowel. Therefore, increasing
10 the hosts ability to maintain such a biotic association would help assure proper nutrition for the host.

Aberrations in the enteric bacterial population of mammals, particularly humans, has been associated with the following disorders: diarrhea, ileus, chronic inflammatory disease, bowel obstruction, duodenal diverticula, biliary calculous
15 disease, and malnutrition. A polynucleotide or polypeptide and/or agonist or antagonist of the present invention are useful for treating, detecting, diagnosing, prognosing, and/or ameliorating, either directly or indirectly, and of the above mentioned diseases and/or disorders associated with aberrant enteric flora population.

The composition of the intestinal flora, for example, is based upon a variety of
20 factors, which include, but are not limited to, the age, race, diet, malnutrition, gastric acidity, bile salt excretion, gut motility, and immune mechanisms. As a result, the polynucleotides and polypeptides, including agonists, antagonists, and fragments thereof, may modulate the ability of a host to form biotic associations by affecting, directly or indirectly, at least one or more of these factors.

25 Although the predominate intestinal flora comprises anaerobic organisms, an underlying percentage represents aerobes (e.g., E. coli). This is significant as such aerobes rapidly become the predominate organisms in intraabdominal infections – effectively becoming opportunistic early in infection pathogenesis. As a result, there is an intrinsic need to control aerobe populations, particularly for immune
30 compromised individuals.

In a preferred embodiment, a polynucleotides and polypeptides, including agonists, antagonists, and fragments thereof, are useful for inhibiting biotic associations with specific enteric symbiont organisms in an effort to control the population of such organisms.

35 Biotic associations occur not only in the gastrointestinal tract, but also on an in the integument. As opposed to the gastrointestinal flora, the cutaneous flora is

5 comprised almost equally with aerobic and anaerobic organisms. Examples of cutaneous flora are members of the gram-positive cocci (e.g., *S. aureus*, coagulase-negative staphylococci, micrococcus, *M.sedentarius*), gram-positive bacilli (e.g., *Corynebacterium* species, *C. minutissimum*, *Brevibacterium* species, *Propionibacterium* species, *P.acnes*), gram-negative bacilli (e.g., *Acinebacter* species), and fungi (*Pityrosporum orbiculare*). The relatively low number of flora associated with the integument is based upon the inability of many organisms to adhere to the skin. The organisms referenced above have acquired this unique ability. Therefore, the polynucleotides and polypeptides of the present invention may have uses which include modulating the population of the cutaneous flora, either directly or indirectly.

Aberrations in the cutaneous flora are associated with a number of significant diseases and/or disorders, which include, but are not limited to the following: impetigo, ecthyma, blistering distal dactulitis, pustules, folliculitis, cutaneous abscesses, pitted keratolysis, trichomycosis axcillaris, dermatophytosis complex, axillary odor, erthyrasma, cheesy foot odor, acne, tinea versicolor, seborrheic dermatitis, and *Pityrosporum folliculitis*, to name a few. A polynucleotide or polypeptide and/or agonist or antagonist of the present invention are useful for treating, detecting, diagnosing, prognosing, and/or ameliorating, either directly or indirectly, and of the above mentioned diseases and/or disorders associated with aberrant cutaneous flora population.

Additional biotic associations, including diseases and disorders associated with the aberrant growth of such associations, are known in the art and are encompassed by the invention. See, for example, "Infectious Disease", Second Edition, Eds., S.L., Gorbach, J.G., Bartlett, and N.R., Blacklow, W.B. Saunders Company, Philadelphia, (1998); which is hereby incorporated herein by reference).

Pheromones

In another embodiment, a polynucleotide or polypeptide and/or agonist or antagonist of the present invention may increase the organisms ability to synthesize, release, and/or respond to a pheromone, either directly or indirectly. Such a pheromone may, for example, alter the organisms behavior and/or metabolism.

A polynucleotide or polypeptide and/or agonist or antagonist of the present invention may modulate the biosynthesis and/or release of pheromones, the organisms ability to respond to pheromones (e.g., behaviorally, and/or metabolically), and/or the organisms ability to detect pheromones, either directly or indirectly. Preferably, any of the pheromones, and/or volatiles released from the organism, or induced, by a polynucleotide or polypeptide and/or agonist or antagonist of the invention have behavioral effects on the organism.

For example, recent studies have shown that administration of picogram quantities of androstadienone, the most prominent androstene present on male human axillary hair and on the male axillary skin, to the female vomeronasal organ resulted in a significant reduction of nervousness, tension and other negative feelings in the female recipients (Grosser-BI, et al., Psychoneuroendocrinology, 25(3): 289-99 (2000)).

Other Activities

20 The polypeptide of the present invention, as a result of the ability to stimulate
vascular endothelial cell growth, may be employed in treatment for stimulating re-
vascularization of ischemic tissues due to various disease conditions such as
thrombosis, arteriosclerosis, and other cardiovascular conditions. These polypeptide
may also be employed to stimulate angiogenesis and limb regeneration, as discussed
25 above.

The polypeptide may also be employed for treating wounds due to injuries, burns, post-operative tissue repair, and ulcers since they are mitogenic to various cells of different origins, such as fibroblast cells and skeletal muscle cells, and therefore, facilitate the repair or replacement of damaged or diseased tissue.

30 The polypeptide of the present invention may also be employed stimulate neuronal growth and to treat, prevent, and/or diagnose neuronal damage which occurs in certain neuronal disorders or neuro-degenerative conditions such as Alzheimer's disease, Parkinson's disease, and AIDS-related complex. The polypeptide of the invention may have the ability to stimulate chondrocyte growth, therefore, they may
35 be employed to enhance bone and periodontal regeneration and aid in tissue transplants or bone grafts.

5 The polypeptide of the present invention may be also be employed to prevent skin aging due to sunburn by stimulating keratinocyte growth.

 The polypeptide of the invention may also be employed to maintain organs before transplantation or for supporting cell culture of primary tissues.

 The polypeptide of the present invention may also be employed for
10 inducing tissue of mesodermal origin to differentiate in early embryos.

 The polypeptide or polynucleotides and/or agonist or antagonists of the present invention may also increase or decrease the differentiation or proliferation of embryonic stem cells, besides, as discussed above, hematopoietic lineage.

 The polypeptide or polynucleotides and/or agonist or antagonists of the
15 present invention may also be used to modulate mammalian characteristics, such as body height, weight, hair color, eye color, skin, percentage of adipose tissue, pigmentation, size, and shape (e.g., cosmetic surgery). Similarly, polypeptides or polynucleotides and/or agonist or antagonists of the present invention may be used to modulate mammalian metabolism affecting catabolism, anabolism, processing,
20 utilization, and storage of energy.

 Polypeptide or polynucleotides and/or agonist or antagonists of the present invention may be used to change a mammal's mental state or physical state by influencing biorhythms, cardiac rhythms, depression (including depressive diseases, disorders, and/or conditions), tendency for violence, tolerance for pain, reproductive
25 capabilities (preferably by Activin or Inhibin-like activity), hormonal or endocrine levels, appetite, libido, memory, stress, or other cognitive qualities.

 Polypeptide or polynucleotides and/or agonist or antagonists of the present invention may also be used as a food additive or preservative, such as to increase or decrease storage capabilities, fat content, lipid, protein, carbohydrate, vitamins,
30 minerals, cofactors or other nutritional components.

 Polypeptide or polynucleotides and/or agonist or antagonists of the present invention may also be used to prepare individuals for extraterrestrial travel, low gravity environments, prolonged exposure to extraterrestrial radiation levels, low oxygen levels, reduction of metabolic activity, exposure to extraterrestrial pathogens,
35 etc. Such a use may be administered either prior to an extraterrestrial event, during an extraterrestrial event, or both. Moreover, such a use may result in a number of

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5 beneficial changes in the recipient, such as, for example, any one of the following, non-limiting, effects: an increased level of hematopoietic cells, particularly red blood cells which would aid the recipient in coping with low oxygen levels; an increased level of B-cells, T-cells, antigen presenting cells, and/or macrophages, which would aid the recipient in coping with exposure to extraterrestrial pathogens, for example; a
10 temporary (i.e., reversible) inhibition of hematopoietic cell production which would aid the recipient in coping with exposure to extraterrestrial radiation levels; increase and/or stability of bone mass which would aid the recipient in coping with low gravity environments; and/or decreased metabolism which would effectively facilitate the recipients ability to prolong their extraterrestrial travel by any one of the following, non-limiting means: (i) aid the recipient by decreasing their basal daily energy
15 requirements; (ii) effectively lower the level of oxidative and/or metabolic stress in recipient (i.e., to enable recipient to cope with increased extraterrestrial radiation levels by decreasing the level of internal oxidative/metabolic damage acquired during normal basal energy requirements; and/or (iii) enabling recipient to subsist at a lower
20 metabolic temperature (i.e., cryogenic, and/or sub-cryogenic environment).

Polypeptide or polynucleotides and/or agonist or antagonists of the present invention may also be used to increase the efficacy of a pharmaceutical composition, either directly or indirectly. Such a use may be administered in simultaneous conjunction with said pharmaceutical, or separately through either the same or
25 different route of administration (e.g., intravenous for the polynucleotide or polypeptide of the present invention, and orally for the pharmaceutical, among others described herein.).

Other Preferred Embodiments

30 Other preferred embodiments of the claimed invention include an isolated nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to a sequence of at least about 50 contiguous nucleotides in the nucleotide sequence of SEQ ID NO:1, or SEQ ID NO:23, wherein X is any integer as defined in Table 1.

35 Also preferred is a nucleic acid molecule wherein said sequence of contiguous nucleotides is included in the nucleotide sequence of SEQ ID NO:1, or SEQ ID

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5 NO:23, in the range of positions beginning with the nucleotide at about the position of the “5’ NT of Start Codon of ORF” and ending with the nucleotide at about the position of the “3’ NT of ORF” as defined for SEQ ID NO:1, or SEQ ID NO:23, in Table 1.

Also preferred is an isolated nucleic acid molecule comprising a nucleotide
10 sequence which is at least 95% identical to a sequence of at least about 150 contiguous nucleotides in the nucleotide sequence of SEQ ID NO:1, or SEQ ID NO:23.

Further preferred is an isolated nucleic acid molecule comprising a nucleotide
15 sequence which is at least 95% identical to a sequence of at least about 500 contiguous nucleotides in the nucleotide sequence of SEQ ID NO:1, or SEQ ID NO:23.

A further preferred embodiment is a nucleic acid molecule comprising a
nucleotide sequence which is at least 95% identical to the nucleotide sequence of SEQ
ID NO:1, or SEQ ID NO:23, beginning with the nucleotide at about the position of
20 the “5’ NT of ORF” and ending with the nucleotide at about the position of the “3’
NT of ORF” as defined for SEQ ID NO:1, or SEQ ID NO:23, in Table 1.

A further preferred embodiment is an isolated nucleic acid molecule
comprising a nucleotide sequence which is at least 95% identical to the complete
nucleotide sequence of SEQ ID NO:1, or SEQ ID NO:23.

25 Also preferred is an isolated nucleic acid molecule which hybridizes under
stringent hybridization conditions to a nucleic acid molecule, wherein said nucleic
acid molecule which hybridizes does not hybridize under stringent hybridization
conditions to a nucleic acid molecule having a nucleotide sequence consisting of only
A residues or of only T residues.

30 Also preferred is a composition of matter comprising a DNA molecule which
comprises a cDNA clone identified by a cDNA Clone Identifier in Table 1, which
DNA molecule is contained in the material deposited with the American Type Culture
Collection and given the ATCC Deposit Number shown in Table 1 for said cDNA
Clone Identifier.

35 Also preferred is an isolated nucleic acid molecule comprising a nucleotide
sequence which is at least 95% identical to a sequence of at least 50 contiguous

5 nucleotides in the nucleotide sequence of a cDNA clone identified by a cDNA Clone Identifier in Table 1, which DNA molecule is contained in the deposit given the ATCC Deposit Number shown in Table 1.

Also preferred is an isolated nucleic acid molecule, wherein said sequence of at least 50 contiguous nucleotides is included in the nucleotide sequence of the complete open reading frame sequence encoded by said cDNA clone.

Also preferred is an isolated nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to sequence of at least 150 contiguous nucleotides in the nucleotide sequence encoded by said cDNA clone.

A further preferred embodiment is an isolated nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to sequence of at least 500 contiguous nucleotides in the nucleotide sequence encoded by said cDNA clone.

A further preferred embodiment is an isolated nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to the complete nucleotide sequence encoded by said cDNA clone.

A further preferred embodiment is a method for detecting in a biological sample a nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to a sequence of at least 50 contiguous nucleotides in a sequence selected from the group consisting of: a nucleotide sequence of SEQ ID NO:1, or SEQ ID NO:23, wherein X is any integer as defined in Table 1; and a nucleotide sequence encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1; which method comprises a step of comparing a nucleotide sequence of at least one nucleic acid molecule in said sample with a sequence selected from said group and determining whether the sequence of said nucleic acid molecule in said sample is at least 95% identical to said selected sequence.

Also preferred is the above method wherein said step of comparing sequences comprises determining the extent of nucleic acid hybridization between nucleic acid molecules in said sample and a nucleic acid molecule comprising said sequence selected from said group. Similarly, also preferred is the above method wherein said step of comparing sequences is performed by comparing the nucleotide sequence

5 Also preferred is a composition of matter comprising isolated nucleic acid molecules wherein the nucleotide sequences of said nucleic acid molecules comprise a panel of at least two nucleotide sequences, wherein at least one sequence in said panel is at least 95% identical to a sequence of at least 50 contiguous nucleotides in a sequence selected from the group consisting of: a nucleotide sequence of SEQ ID
10 NO:1, or SEQ ID NO:23, wherein X is any integer as defined in Table 1; and a nucleotide sequence encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1. The nucleic acid molecules can comprise DNA molecules or RNA molecules.

15 Also preferred is an isolated polypeptide comprising an amino acid sequence at least 90% identical to a sequence of at least about 10 contiguous amino acids in the amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in Table 1.

Also preferred is a polypeptide, wherein said sequence of contiguous amino
20 acids is included in the amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, in the range of positions "Total AA of the Open Reading Frame (ORF)" as set forth for SEQ ID NO:2, or SEQ ID NO:24, in Table 1.

Also preferred is an isolated polypeptide comprising an amino acid sequence at least 95% identical to a sequence of at least about 30 contiguous amino acids in the
25 amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24.

Further preferred is an isolated polypeptide comprising an amino acid sequence at least 95% identical to a sequence of at least about 100 contiguous amino acids in the amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24.

Further preferred is an isolated polypeptide comprising an amino acid
30 sequence at least 95% identical to the complete amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24.

Further preferred is an isolated polypeptide comprising an amino acid sequence at least 90% identical to a sequence of at least about 10 contiguous amino acids in the complete amino acid sequence of a protein encoded by a cDNA clone
35 identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

5 Also preferred is a polypeptide wherein said sequence of contiguous amino acids is included in the amino acid sequence of the protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

10 Also preferred is an isolated polypeptide comprising an amino acid sequence at least 95% identical to a sequence of at least about 30 contiguous amino acids in the amino acid sequence of the protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

15 Also preferred is an isolated polypeptide comprising an amino acid sequence at least 95% identical to a sequence of at least about 100 contiguous amino acids in the amino acid sequence of the protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

20 Also preferred is an isolated polypeptide comprising an amino acid sequence at least 95% identical to the amino acid sequence of the protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

25 Further preferred is an isolated antibody which binds specifically to a polypeptide comprising an amino acid sequence that is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in Table 1; and a complete amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

30 Further preferred is a method for detecting in a biological sample a polypeptide comprising an amino acid sequence which is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in Table 1; and a complete amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1

5 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1; which method comprises a step of comparing an amino acid sequence of at least one polypeptide molecule in said sample with a sequence selected from said group and determining whether the sequence of said polypeptide molecule in said sample is at least 90% identical to said sequence of at least 10 contiguous
10 amino acids.

Also preferred is the above method wherein said step of comparing an amino acid sequence of at least one polypeptide molecule in said sample with a sequence selected from said group comprises determining the extent of specific binding of polypeptides in said sample to an antibody which binds specifically to a polypeptide
15 comprising an amino acid sequence that is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in Table 1; and a complete amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the
20 deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

Also preferred is the above method wherein said step of comparing sequences is performed by comparing the amino acid sequence determined from a polypeptide molecule in said sample with said sequence selected from said group.

Also preferred is a method for identifying the species, tissue or cell type of a
25 biological sample which method comprises a step of detecting polypeptide molecules in said sample, if any, comprising an amino acid sequence that is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in Table 1; and a complete amino acid
30 sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

Also preferred is the above method for identifying the species, tissue or cell type of a biological sample, which method comprises a step of detecting polypeptide
35 molecules comprising an amino acid sequence in a panel of at least two amino acid sequences, wherein at least one sequence in said panel is at least 90% identical to a

5 sequence of at least 10 contiguous amino acids in a sequence selected from the above group.

Also preferred is a method for diagnosing a pathological condition associated with an organism with abnormal structure or expression of a gene encoding a protein identified in Table 1, which method comprises a step of detecting in a biological
10 sample obtained from said subject polypeptide molecules comprising an amino acid sequence in a panel of at least two amino acid sequences, wherein at least one sequence in said panel is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as defined in
15 Table 1; and a complete amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

In any of these methods, the step of detecting said polypeptide molecules includes using an antibody.

20 Also preferred is an isolated nucleic acid molecule comprising a nucleotide sequence which is at least 95% identical to a nucleotide sequence encoding a polypeptide wherein said polypeptide comprises an amino acid sequence that is at least 90% identical to a sequence of at least 10 contiguous amino acids in a sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or
25 SEQ ID NO:24, wherein Y is any integer as defined in Table 1; and a complete amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

Also preferred is an isolated nucleic acid molecule, wherein said nucleotide
30 sequence encoding a polypeptide has been optimized for expression of said polypeptide in a prokaryotic host.

Also preferred is an isolated nucleic acid molecule, wherein said polypeptide comprises an amino acid sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is any integer as
35 defined in Table 1; and a complete amino acid sequence of a protein encoded by a

5 cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1.

Further preferred is a method of making a recombinant vector comprising inserting any of the above isolated nucleic acid molecule(s) into a vector. Also preferred is the recombinant vector produced by this method. Also preferred is a method of making a recombinant host cell comprising introducing the vector into a host cell, as well as the recombinant host cell produced by this method.

Also preferred is a method of making an isolated polypeptide comprising culturing this recombinant host cell under conditions such that said polypeptide is expressed and recovering said polypeptide. Also preferred is this method of making an isolated polypeptide, wherein said recombinant host cell is a eukaryotic cell and said polypeptide is a protein comprising an amino acid sequence selected from the group consisting of: an amino acid sequence of SEQ ID NO:2, or SEQ ID NO:24, wherein Y is an integer set forth in Table 1 and said position of the "Total AA of ORF" of SEQ ID NO:2, or SEQ ID NO:24, is defined in Table 1; and an amino acid sequence of a protein encoded by a cDNA clone identified by a cDNA Clone Identifier in Table 1 and contained in the deposit with the ATCC Deposit Number shown for said cDNA clone in Table 1. The isolated polypeptide produced by this method is also preferred.

Also preferred is a method of treatment of an individual in need of an increased level of a protein activity, which method comprises administering to such an individual a pharmaceutical composition comprising an amount of an isolated polypeptide, polynucleotide, or antibody of the claimed invention effective to increase the level of said protein activity in said individual.

Having generally described the invention, the same will be more readily understood by reference to the following examples, which are provided by way of illustration and are not intended as limiting.

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35

Examples

5

Description of the Preferred Embodiments

Example 1 – Bioinformatics Analysis For K+betaM4 and K+betaM5.

In the case of K+betaM4, ion channel sequences were used as probes to search the human genomic sequence database. The search program used was gapped BLAST (Altschul et al., 1997). Ion channel specific Hidden Markov Models (HMMs) built in-house or obtained from the public PFAM databases were also used as probes

10 house or obtained from the public PFAM databases were also used as probes (Bateman et al., 2000). The search program used for HMMs was the Genewise/Wise2 package (<http://www.sanger.ac.uk/Software/Wise2/index.shtml>) . The top genomic exon hits from the results were searched back against the non-redundant protein and patent sequence databases. From this analysis BAC U73643 was determined to

15 possess a novel ion channel exon based on its homology to the putative human beta subunit K+Hnov28 (SEQ ID NO:3). A predicted exon sequence from BAC U73643, including 200bp of intron sequence on either side is provided as SEQ ID NO:8. The full length cDNA described herein as K+betaM4 (SEQ ID NO:1, Figures 1A-B), was isolated using probes designed from the BAC U73643 exon (SEQ ID NO:8). Based

20 on this analysis, a partial sequence of the novel human ion channel related gene, K+betaM4, was identified directly from the genomic sequence. The full-length clone of this novel ion channel gene was experimentally obtained by using the sequence from genomic data.

In the case of K+betaM5, ion channel sequences were used as probes to search

25 the human genomic sequence database. The search program used was gapped BLAST (Altschul et al., 1997). Ion channel specific Hidden Markov Models (HMMs) built in-house or obtained from the public PFAM databases were also used as probes (Bateman et al., 2000). The search program used for HMMs was the Genewise/Wise2 package (<http://www.sanger.ac.uk/Software/Wise2/index.shtml>) . The top genomic

30 exon hits from the results were searched back against the non-redundant protein and patent sequence databases. From this analysis BAC AC006001 was determined to possess a novel ion channel exon based on its homology to the putative human beta subunit K+Hnov28 (SEQ ID NO:3). A predicted exon sequence from BAC AC006001, including 200bp of intron sequence on either side is provided as SEQ ID

35 NO:29. Based on this analysis, a partial sequence of the novel human ion channel related gene, K+betaM5, was identified directly from the genomic sequence. The full-

5 length clone of this novel ion channel gene was experimentally obtained by using the sequence from genomic data. The full length cDNA described herein as K+betaM5 (SEQ ID NO:23, Figures 6A-C), was isolated using probes designed from the BAC AC006001 exon (SEQ ID NO:29).

10 **Example 2 - Method for Constructing a size fractionated brain and testis cDNA Library**

Brain and testis poly A + RNA was purchased from Clontech and converted into double stranded cDNA using the SuperScript™ Plasmid System for cDNA
15 Synthesis and Plasmid Cloning (Life Technologies) except that no radioisotope was incorporated in either of the cDNA synthesis steps and that the cDNA was fractionated by HPLC. This was accomplished on a TransGenomics HPLC system equipped with a size exclusion column (TosoHass) with dimensions of 7.8mm x 30cm and a particle size of 10µm. Tris buffered saline was used as the mobile phase and the
20 column was run at a flow rate of 0.5 mL/min.

The resulting chromatograms were analyzed to determine which fractions should be pooled to obtain the largest cDNA's; generally fractions that eluted in the range of 12 to 15 minutes were pooled. The cDNA was precipitated prior to ligation into the Sal I / Not I sites in the pSport vector supplied with the kit. Using a
25 combination of PCR with primers to the ends of the vector and Sal I/Not I restriction enzyme digestion of mini-prep DNA, it was determined that the average insert size of the library was greater the 3.5 Kb. The overall complexity of the library was greater that 10^7 independent clones. The library was amplified in semi-solid agar for 2 days at 30° C. An aliquot (200 microliters) of the amplified library was inoculated into a 200
30 ml culture for single-stranded DNA isolation by super-infection with a fl helper phage. After overnight growth, the released phage particles with precipitated with PEG and the DNA isolated with proteinase K, SDS and phenol extractions. The single stranded circular DNA was concentrated by ethanol precipitation and used for the cDNA capture experiments.

35

Example 3 - Cloning of the Novel Human Potassium Channel, K+betaM4 or K+betaM5.

5 In the case of K+betaM4, the predicted exon genomic sequence from bac U73643 was used to design an antisense 80 bp oligo with biotin on the 5' end with the following sequence:

5'-

10 bTTGAGGATATAGCGGAACACTTTGCCGTCACGGTCAATGAAGCAGTTGCCCTGGCT
GTCCCTCTTGGTGGGCAT-3' (SEQ ID NO:9)

15 In the case of K+betaM5, the predicted exon genomic sequence from bac AC006001 was used to design an antisense 80 bp oligo with biotin on the 5' end with the following sequence:

5'GATGAAGTACCGGCCCTCGGAGTCCGTGGGGATGTAGTGCCGCCCACTGAACATGGCT
GCCAACATGGTGTCTTCGTAGC -3' (SEQ ID NO:30)

20

One microliter (one hundred and fifty nanograms) of the biotinylated oligo was added to six microliters (six micrograms) of a single-stranded covalently closed circular brain and testis cDNA library (see Example 2) and seven microliters of 100% formamide in a 0.5 ml PCR tube. The mixture was heated in a thermal cycler to 95° C for 2 mins. Fourteen microliters of 2X hybridization buffer (50% formamide, 1.5 M NaCl, 0.04 M NaPO₄, pH 7.2, 5 mM EDTA, 0.2% SDS) was added to the heated probe/cDNA library mixture and incubated at 42° C for 26 hours. Hybrids between the biotinylated oligo and the circular cDNA were isolated by diluting the hybridization mixture to 220 microliters in a solution containing 1 M NaCl, 10 mM Tris-HCl pH 7.5, 1mM EDTA, pH 8.0 and adding 125 microliters of streptavidin
30 magnetic beads. This solution was incubated at 42° C for 60 mins, mixing every 5 mins to resuspend the beads. The beads were separated from the solution with a magnet and the beads washed three times in 200 microliters of 0.1 X SSPE, 0.1% SDS at 45° C.

35 The single stranded cDNAs were release from the biotinlyated oligo/streptavidin magnetic bead complex by adding 50 microliters of 0.1 N NaOH and incubating at room temperature for 10 mins. Six microliters of 3 M Sodium

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5 Acetate was added along with 15 micrograms of glycogen and the solution ethanol precipitated with 120 microliters of 100% ethanol. The DNA was resuspend in 12 microliters of TE (10 mM Tris-HCl, pH 8.0), 1mM EDTA, and pH 8.0). The single stranded cDNA was converted into double strands in a thermal cycler by mixing 5 microliters of the captured DNA with 1.5 microliters 10 micromolar standard SP6
10 primer (homologous to a sequence on the cDNA cloning vector) and 1.5 microliters of 10 X PCR buffer. The mixture was heated to 95° C for 20 seconds, then ramped down to 59 ° C. At this time 15 microliters of a repair mix, that was preheated to 70° C (Repair mix contains 4 microliters of 5 mM dNTPs (1.25 mM each), 1.5 microliters of 10X PCR buffer, 9.25 microliters of water, and 0.25 microliters of Taq polymerase).
15 The solution was ramped back to 73° C and incubated for 23 mins. The repaired DNA was ethanol precipitate and resuspended in 10 microliters of TE. Two microliters were electroporated in E. coli DH12S cells and resulting colonies were screen by PCR, using a primer pair designed from the genomic exonic sequence to identify the proper cDNAs.

20

The following oligos were used to identity the K+betaM4 cDNA by PCR:

2BAC-18s ATACAACCTCACTGGCGACC (SEQ ID NO:10)

2BAC-18a CCATCTCCTGGAAGTCCTCA (SEQ ID NO:11)

Those cDNA clones that were positive by PCR had the inserts sized and two
25 clones were chosen for DNA sequencing. Both clones had identical sequence. The sequence is provided in Figures 1A-B (SEQ ID NO:1).

The following oligos were used to identity the K+betaM5 cDNA by PCR:

2BAC-3s TGTTCCTTAACATCGGAG (SEQ ID NO:31)

2BAC-3a CATACCAAAGTGTGTGCCA (SEQ ID NO:32)

30

5 Those cDNA clones that were positive by PCR had the inserts sized and two clones were chosen for DNA sequencing. Both clones had identical sequence. The sequence is provided in Figures 6A-C (SEQ ID NO:23).

10 **Example 4 – Expression profiling of novel human potassium channel modulatory beta subunit K+betaM4 and K+betaM5**

The same PCR primer pair (SEQ ID NO:10 and 11) that was used to identify the K+betaM4 cDNA clone, in addition to the same PCR primer pair (SEQ ID NO:31 and 32) that was used to identify the K+betaM5 cDNA clone, was used to measure their respective steady state levels of mRNA by quantitative PCR. Briefly, first strand
15 cDNA was made from commercially available mRNA (Clontech) and subjected to real time quantitative PCR using a PE 5700 instrument (Applied Biosystems, Foster City, CA) which detects the amount of DNA amplified during each cycle by the fluorescent output of SYBR green, a DNA binding dye specific for double strands. The specificity of the primer pair for its target is verified by performing a thermal
20 denaturation profile at the end of the run which gives an indication of the number of different DNA sequences present by determining melting T_m. In the case of the K+betaM4 and K+betaM5 primer pairs, only one DNA fragment was detected having a homogeneous melting point. Contributions of contaminating genomic DNA to the assessment of tissue abundance is controlled for by performing the PCR with first
25 strand made with and without reverse transcriptase. In all cases, the contribution of material amplified in the no reverse transcriptase controls was negligible.

Small variations in the amount of cDNA used in each tube was determined by performing a parallel experiment using a primer pair for a gene expressed in equal amounts in all tissues, cyclophilin. These data were used to normalize the data
30 obtained with the K+betaM4 and K+betaM5 primer pairs. The PCR data was converted into a relative assessment of the difference in transcript abundance amongst the tissues tested and the data are presented in bar graph form.

Transcripts corresponding to K+betaM4 were expressed highly in the liver and spinal cord; significantly in small intestine, testis, stomach, and to a lesser extent, in
35 heart, lymph node, uterus, kidney, and prostate (as shown in Figure 3).

- 5 Transcripts corresponding to K+betaM5 were expressed highly in the testis; significantly in spinal cord, lymph node, heart, uterus, and to a lesser extent, in small intestine, stomach, prostate, and kidney (as shown in Figure 8).

10 **Example 5 – Method Of Assessing The Expression Profile Of The Novel K+betaM4 and K+betaM5 Polypeptides Of The Present Invention Using Expanded mRNA Tissue and Cell Sources**

Total RNA from tissues was isolated using the TriZol protocol (Invitrogen) and quantified by determining its absorbance at 260nm. An assessment of the 18s and 28s ribosomal RNA bands was made by denaturing gel electrophoresis to determine
 15 RNA integrity.

The specific sequence to be measured was aligned with related genes found in GenBank to identity regions of significant sequence divergence to maximize primer and probe specificity. Gene-specific primers and probes were designed using the ABI primer express software to amplify small amplicons (150 base pairs or less) to
 20 maximize the likelihood that the primers function at 100% efficiency. All primer/probe sequences were searched against Public Genbank databases to ensure target specificity. Primers and probes were obtained from ABI.

For K+betaM4 or K+betaM5, the primer probe sequences were as follows

25

Forward Primer	5'- GTGCCGCATTTATCCATCTGT -3' (SEQ ID NO:45)
Reverse Primer	5'- TGGAGGTAGCCTCTTGTTCAT -3' (SEQ ID NO:46)
TaqMan Probe	5' – CCATCCTCTCCACCAGGGCCTTCT -3' (SEQ ID NO:47)

30 For K+betaM5, the primer probe sequences were as follows

Forward Primer	5'- TGCCCCCTGGAGTCACAT -3' (SEQ ID NO:48)
Reverse Primer	5'- GGACCAATGGGAGTTTCAA -3' (SEQ ID NO:49)
TaqMan Probe	5' – CAGCCGCCTTTCTGCGTTAATCCAT -3' (SEQ ID NO:50)

35

5 *DNA contamination*

To access the level of contaminating genomic DNA in the RNA, the RNA was divided into 2 aliquots and one half was treated with Rnase-free Dnase (Invitrogen). Samples from both the Dnase-treated and non-treated were then subjected to reverse transcription reactions with (RT+) and without (RT-) the presence of reverse transcriptase. TaqMan assays were carried out with gene-specific primers (see above) and the contribution of genomic DNA to the signal detected was evaluated by comparing the threshold cycles obtained with the RT+/RT- non-Dnase treated RNA to that on the RT+/RT- Dnase treated RNA. The amount of signal contributed by genomic DNA in the Dnased RT- RNA must be less than 10% of that obtained with Dnased RT+ RNA. If not the RNA was not used in actual experiments.

Reverse Transcription reaction and Sequence Detection

100ng of Dnase-treated total RNA was annealed to 2.5 μ M of the respective gene-specific reverse primer in the presence of 5.5 mM Magnesium Chloride by heating the sample to 72°C for 2 min and then cooling to 55° C for 30 min. 1.25 U/ μ l of MuLv reverse transcriptase and 500 μ M of each dNTP was added to the reaction and the tube was incubated at 37° C for 30 min. The sample was then heated to 90°C for 5 min to denature enzyme.

Quantitative sequence detection was carried out on an ABI PRISM 7700 by adding to the reverse transcribed reaction 2.5 μ M forward and reverse primers, 500 μ M of each dNTP, buffer and 5U AmpliTaq Gold™. The PCR reaction was then held at 94°C for 12 min, followed by 40 cycles of 94° C for 15 sec and 60° C for 30 sec.

Data handling

The threshold cycle (Ct) of the lowest expressing tissue (the highest Ct value) was used as the baseline of expression and all other tissues were expressed as the relative abundance to that tissue by calculating the difference in Ct value between the baseline and the other tissues and using it as the exponent in $2^{(\Delta Ct)}$

The expanded expression profile of the K+betaM4 polypeptide, is provided in Figure 5 and is described elsewhere herein.

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5 The expanded expression profile of the K+betaM5 polypeptide, is provided in Figure 10 and is described elsewhere herein.

Example 6 - Method of Associating The K+betaM5 Polypeptide To The NF-kB Pathway.

10

Identification of A Putative Drosophila Ortholog of K+betaM5

To search the Drosophila orthologue of human K+betaM5 gene, the K+betaM5 protein sequence (SEQ ID NO:24) was searched against the public Drosophila protein and genomic sequence database from GenBank, using the BLAST software(1). A Drosophila gene CG10465 (SEQ ID NO:27; Genbank Accession No: 17946205) was found to have significant homology with the human K+betaM5 gene, with 30.8% identity (38.3% similarity) at the amino acid level covering the majority of the gene as determined by the GAP global alignment algorithm using default parameters. The results of this preliminary database search suggested that CG10465 may be the putative Drosophila orthologue of the human K+betaM5 gene. In addition, the CG10465 protein has significant homologue to all K+channel tetramerisation domain proteins, as evidenced by its identity to the K_tetra PF02214 K+ channel tetramerisation domain Pfam hidden markov model (shown below). Due to the significant level of homology between the proteins, studies with CG10465 were undertaken in a Drosophila cell-based model for immunity.

CG10465 Pfam Alignment
D = K_tetra PF02214 K+ channel tetramerisation domain
30 Identical Match = 31 Similar = 76 Total # Of Gaps = 3
Identity: Alignment = 28% Query = 10% Target = 28%
Similarity: Alignment = 68% Query = 25% Target = 68%
QS = 19 QE = 117 TS = 1 TE = 111

35 Q 19 QYLKLVGGHLYTTIGTLTKN-NDTMLSAMFSGR-----MEVLTDSEGWILDR
+ ++LNVGG ++T+ TL++ DT+L+ +++++ ++ +D ++++ +DR
T 1 ERVRLNVGGKRFETWWSTLMRFKPDTRLGRCLKCSDVHEERMWCFYDDDDTNEYFFDR

40 Q 68 CGNHFGIILNYLRDGTVPETNKEIAELLAEAKYYCITEL-AISCERALY
+ HF +ILNY+R+G++ L++ +++++ ++L+EA+++ I+EL +C ++ Y
T 61 HPKHFRHILNYYRTGDGKLHCPMECVDSFLEAEFWGIDELHIEDCCWDEY

45 The experiments described herein correlate the function of the CG10465 protein to the regulation of the Drosophila innate immune response. Central to these

5 studies was the generation of a “knock out” phenotype with double-stranded RNA-mediated interference (RNAi) of CG10465 mRNA in *Drosophila* Schneider 2 (S2) cultured cells. RNAi technologies were developed to produce sustained post-transcriptional gene-silencing and have been reported to work in S2 cells (Caplen et al., 2000; Clemens et al., 2000). S2 cells can be induced by the bacterial cell wall component lipopolysaccharide (LPS) to express a subset of antimicrobial peptides including attacin (Han and Ip, 1999). Experiments presented here test CG10465 RNAi in a LPS-inducible luciferase reporter system in S2 cells.

Methods

15 A stable S2 cell line was generated with an LPS-responsive AttacinD promoter fused to a luciferase reporter. S2 cells were purchased from Invitrogen and maintained at 25° C in complete 1x Schneider's *Drosophila* medium (Cat. No. 11720-034, Invitrogen, former GIBCO BRL) supplemented with 10% heat-inactivated fetal bovine serum (Cat. No. 10100-147, Invitrogen, former GIBCO BRL), 100 units/ml of penicillin, 100 ug/ml of streptomycin (100 X stock of Penicillin-Streptomycin, cat. No. 15140-148, from Invitrogen, former GIBCO BRL) and 20 mM L-Glutamine (100 x L-Glutamine, cat.No. 25030-149, from Invitrogen, former GIBCO BRL). A 1.6 Kb promoter region of the attacinD AMP gene was isolated from S2 genomic DNA by PCR using the primer pair: ATGAGGCTTGGATCAGCTTT (SEQ ID NO:52) (forward, 157904-157923bp of AE003718 *Drosophila* Genome project) and CCTGAAGCCTGACATTCCAT (SEQ ID NO:53) (reversed, 159547-159566bp of AE003718). Primers were obtained from GIBCOBRL. PCR condition : 96°C 4min, 94°C 2 min, 55°C 45 seconds, 72°C 2min, PCR 35 cycles. The 1.6kb attacinD PCR fragment was subcloned into a pCR2.1-TOPO vector (TOPO TA Cloning Kits, cat. No. K4500-01, Invitrogen). The attacinD promoter was subcloned from pCR2.1-TOPO vector into pGL3-Enhancer luciferase vector with restriction enzyme Sac I and Xho I (pGL3-Enhancer luciferase reporter vector, cat.no. E1771, Promega). A similar region was shown to be LPS responsive in a reporter assay (Tauszig et al., 2000). A final transfection construct, pGL3-enhancer- attacinD, was cotransfected with calcium phosphate methods with pCoHYGRO plasmid providing the hygromycin-B resistant

35

5 gene as a stable selection, were used to transfect S2 cells (Inducible DES Kit, cat. No. K4120-01, Drosophila Expression System Instruction Manual, p16 from Invitrogen).

Briefly 19 ug of pGL3-enhancer- attacinD DNA was mixed with 1 ug of pCoHYGRO DNA and transfection buffer were used to transfect 6-12 X 10⁶ cells/3 mls/well in 6-well Falcon tissue culture plate. Stable cells were selected and
 10 maintained in complete Schneider's medium containing 300ug/ml Hygromycin-B (Cat. R220-05, Invitrogen). Stable lines were tested for responsiveness to LPS (Han and Ip, 1999). Cells were treated with 20ug/ml LPS (Cat. No L-2654, Sigma) for 5 hours. Expression of luciferase was assayed with Bright-Glo™ Luciferase Assay System (cat. No. E2620, Promega) and the luminescence signal was detected by 1450
 15 MICROBETA Wallac Jet Liquid Scintillation & Luminescence Counter (Perkin Elmer Life Sciences). Two stable AttD-luc reporter cell lines (E4-1 and E4-9) were obtained after three rounds of limiting dilution and used for further studies.

RNAi constructs were made for CG10465 and control genes as follows. Complementary DNA (cDNA) clones for Drosophila genes were obtained from
 20 Research Genetics, Inc (St. Louis, Mo). These include the cDNAs from Relish (EST GH01881), IKKB (EST LD21354), Cactus (LD18620), and CG10465 (LD45748) (Rubin et al., 2000). Double-stranded RNAi generation followed a modified protocol of (Hammond et al., 2000). Briefly, dsRNA was synthesized from a template amplified by PCR with T7 promoter sequences flanking the cDNA insert using the
 25 MEGAscript™ T7 High Yield Transcription Kit (cat. No. 1334, Ambion). GH0881, LD 21354, and LD45748 were in the pOT2 vector (forward primer: ACTGCAGCCGATTCATTAATG (SEQ ID NO:54), reverse primer: GAATTAATACGACTCACTATAGGGAGATATCATACACATACGATTTAG (SEQ ID NO:55)) and LD18620 was in a pBS vector (forward primer:
 30 GAATTAATACGACTCACTATAGGGAGACATGATTACGCCAAGCTCGAA (SEQ ID NO:56) reverse primer: TGTAACGACGGCCAGTGAA (SEQ ID NO:57)). dsRNA was diluted at 1:5 and denatured prior to addition to E4-1 and E4-9 cells.

Transfection of dsRNA into S2 cells was performed by adding dsRNA directly
 35 into S2 cells in serum free medium (Clemens et al., 2000). Prior to transfection, cells were split about 24 hours before transfection at 1x 10⁶ cells/ml in complete 1x

5 Schneider medium. Immediately preceding the transfection, cells were washed twice with serum free DES Expression Medium (cat. No. Q500-01, Invitrogen) and resuspended in serum free DES medium at 7×10^5 cells/ml. 100ul cells were added to each well in 96-well-plates (Falcon tissue culture plates), then 5 ul dsRNA/well was added, followed by vigorous shaking for 45 minutes to 1 hour, and then 150 ul
 10 complete 1xSchneider medium/well was added. 96-well-plates were wrapped with Saran wrap before incubating at 25°C. After 3 days incubation, each dsRNA treated cells were split into duplicate for the luciferase assay, and in triplicate for the proliferation assay.

5-15 ul cells in 100ul total volume were used for the luciferase assay, and 30-
 15 35ul cells in 100ul total volume were used for the proliferation assay. Luciferase assay plates were incubated for 5 hours after adding LPS at 20ug/ml. Proliferation assay plates were incubated for 2-3 hours before reading 490nm Optical Density. (CellTiter 96 Aqueous One Solution Cell Proliferation Assay from Promega, Cat. No. G3580).

20 Results presented below represent results of one experiment with E4-1 cells averaged in duplicate relative to control samples. Changes are relative to 1 depict fold change in luciferase experssion after normalization with cell number obtained in the proliferation assay. Similar results were obtained in 4 separate experiments and with the E4-9 stable cell line. NS is nonstimulated, LPS represents LPS treatment as
 25 described above.

	NS	LPS
Control	1.2	0.8
CG10465	0.36	0.37
IκKB	0.33	0.2
Relish	0.12	0.01
Cactus	6.9	9.65

30 The results indicate that the physiological function of the CG10465 protein is to serve as a positive regulator in an innate immunity model in Drosophila cells with a similar profile as IκKB. RNAi experiments of positive regulators of this signaling pathway were found to have low luciferase activity as demonstrated with IκKB and

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- 5 Relish (Silverman et al., 2000). These results demonstrate that CG10465 regulates the LPS-response pathway. Similarly, K+betaM5 is likely to have a similar role in mammalian immunity pathways.

5

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- 35

5 **Example 7 – Method of assessing ability of K+betaM4 or K+betaM5 polypeptides to associate with potassium channel subunits using the yeast two-hybrid system.**

 In an effort to determine whether the K+betaM4 or K+betaM5 polypeptides of the present invention are capable of functioning as potassium channel alpha subunits,
10 it would be important to effectively test the interaction between K+betaM4 or K+betaM5 and various portions of other potassium channel alpha or beta subunits, in a yeast two-hybrid system. Such a system could be created using methods known in the art (see, for example, S. Fields and O. Song, Nature, 340:245-246 (1989); and Gaston-SM and Loughlin-KR, Urology, 53(4): 835-42 (1999); which are hereby
15 incorporated herein by reference in their entirety, including the articles referenced therein).

 Cytoplasmic NH and COOH terminal domains of different potassium channel alpha- or beta-subunits could be subcloned and expressed as fusion proteins of the GAL4 DNA binding (DB) domain using molecular biology techniques within the skill
20 of the artisan.

 Exemplary subunits which could be used in the two-hybrid system to assess K+betaM4 or K+betaM5s ability to associate with other alpha or beta subunits include, but are not limited to, the NH.sub.2 -terminal domain of the rat Kv9.3, human Shab-related subunit, the human Kv8.1, the Drosophila Shab11 of the Kv2 subfamily,
25 the Shaw2 of the Kv3 subfamily, or the Shal2 of the Kv4 subfamily.

30 **Example 8 – Method of assessing ability of K+betaM4 or K+betaM5 polypeptides to form oligomeric complexes with itself or other potassium channel subunits in solution.**

 Aside from determining whether the K+betaM4 or K+betaM5 polypeptides are capable of interacting with other potassium channel alpha and/or beta subunits in a yeast two-hybrid assay, it would be an important next step to assess its ability to form
35 oligomeric complexes with itself, in addition to other alpha or beta subunits in solution. Such a finding would be significant as it would provide convincing evidence

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5 that K+betaM4 or K+betaM5 could serve as a potassium channel alpha subunit and may modulate potassium channel function.

A number of methods could be used to that are known in the art, for example, the method described by Sanguinetti, M.C., et al., Nature, 384:80-83 (1996) could be adapted using methods within the skill of the artisan.

10

Example 9 – Method of assessing whether the formation of K+betaM4 or K+betaM5/potassium channel subunits has any effect on inhibiting potassium channel function.

Once the K+betaM4 or K+betaM5 polypeptides are determined to form
 15 oligomeric and/or heteromultimeric complexes with other alpha or beta subunits, it would be important to determine whether such an interaction is physiologically relevant. Alternatively, this experiment could be performed prior to the oligomerization and yeast-two hybrid experiments described above.

Expression constructs comprising the coding region of the K+betaM4 or
 20 K+betaM5 polypeptide under the control of a constitutive or inducible promoter could be created and used to transiently or stably transfect a cell line lacking endogenous potassium channel alpha expression. Once transfected, the ability of the cells to transduce K+ could be assessed using techniques known in the art. Alternatively, any cell line could be transfected with K+betaM4 or K+betaM5 polypeptides and the
 25 potassium channel function of the cell assessed. Alternatively, oocytes from the South African clawed frog *X. laevis* could be used to assess the ability of expressed K+betaM4 or K+betaM5 polypeptides to modulate endogenous or transfected potassium channel function (for example, Wagner-CA; Friedrich-B; Setiawan-I; Lang-F; Broer, Cell-Physiol-Biochem., 10(1-2):1-12 (2000); which is hereby
 30 incorporated herein by reference in its entirety, including the references cited therein). Additional methods could be applied for assessing the ability of K+betaM4 or K+betaM5 to modulate potassium channel activity. For example, the method described by McDonald, T.V., et al., Nature, 388:289-292 (1997) could be adapted using methods within the skill of the artisan.

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5 **Example 10 – Method of identifying the cognate ligand of the K+betaM4 and K+betaM5 polypeptides.**

A number of methods are known in the art for identifying the cognate binding partner of a particular polypeptide. For example, the encoding K+betaM4 or K+betaM5 polynucleotide could be engineered to comprise an epitope tag. The epitope could be any epitope known in the art or disclosed elsewhere herein. Once created, the epitope tagged K+betaM4 or K+betaM5 encoding polynucleotide could be cloned into an expression vector and used to transfect a variety of cell lines representing different tissue origins (e.g., brain, testis, etc.). The transfected cell lines could then be induced to overexpress the K+betaM4 or K+betaM5 polypeptide. Since other electrically silent channels appear to remain in the endoplasmic reticulum in the absence of their cognate binding partner, evidence for a cell type expressing the proper conducting channel would be the observed cell surface expression of K+betaM4 or K+betaM5. The presence of the K+betaM4 or K+betaM5 polypeptide on the cell surface could be determined by fractionating whole cell lysates into cellular and membrane protein fractions and performing immunoprecipitation using the antibody directed against the epitope engineered into the K+betaM4 or K+betaM5 polypeptide. Monoclonal or polyclonal antibodies directed against the K+betaM4 or K+betaM5 polypeptide could be created and used in place of the antibodies directed against the epitope.

Alternatively, the cell surface proteins could be distinguished from cellular proteins by biotinylating the surface proteins and then performing immunoprecipitations with antibody specific to the K+betaM4 or K+betaM5 protein. After electrophoretic separation, the biotinylated protein could be detected with streptavidin-HRP (using standard methods known to those skilled in the art). Identification of the proteins bound to K+betaM4 or K+betaM5 could be made in those cells by immunoprecipitation, followed by one-dimensional electrophoresis, followed by various versions of mass spectrometry. Such mass-spectrometry methods are known in the art, such as for example the methods taught by CIPHERGEN Biosystems Inc. (see US Patent No. 5,792,664; which is hereby incorporated herein by reference).

5 **Example 11 - Isolation of a Specific Clone from the Deposited Sample.**

 The deposited material in the sample assigned the ATCC Deposit Number cited in Table 1 for any given cDNA clone also may contain one or more additional plasmids, each comprising a cDNA clone different from that given clone. Thus, deposits sharing the same ATCC Deposit Number contain at least a plasmid for each
10 cDNA clone identified in Table 1. Typically, each ATCC deposit sample cited in Table 1 comprises a mixture of approximately equal amounts (by weight) of about 1-10 plasmid DNAs, each containing a different cDNA clone and/or partial cDNA clone; but such a deposit sample may include plasmids for more or less than 2 cDNA clones.

15 Two approaches can be used to isolate a particular clone from the deposited sample of plasmid DNA(s) cited for that clone in Table 1. First, a plasmid is directly isolated by screening the clones using a polynucleotide probe corresponding to SEQ ID NO:1, or SEQ ID NO:23.

 Particularly, a specific polynucleotide with 30-40 nucleotides is synthesized
20 using an Applied Biosystems DNA synthesizer according to the sequence reported. The oligonucleotide is labeled, for instance, with ³²P-(-ATP using T4 polynucleotide kinase and purified according to routine methods. (E.g., Maniatis et al., Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press, Cold Spring, NY (1982).) The plasmid mixture is transformed into a suitable host, as indicated above (such as
25 XL-1 Blue (Stratagene)) using techniques known to those of skill in the art, such as those provided by the vector supplier or in related publications or patents cited above. The transformants are plated on 1.5% agar plates (containing the appropriate selection agent, e.g., ampicillin) to a density of about 150 transformants (colonies) per plate. These plates are screened using Nylon membranes according to routine methods for
30 bacterial colony screening (e.g., Sambrook et al., Molecular Cloning: A Laboratory Manual, 2nd Edit., (1989), Cold Spring Harbor Laboratory Press, pages 1.93 to 1.104), or other techniques known to those of skill in the art.

 Alternatively, two primers of 17-20 nucleotides derived from both ends of the SEQ ID NO:1, or SEQ ID NO:23, (i.e., within the region of SEQ ID NO:1, or SEQ ID
35 NO:23, bounded by the 5' NT and the 3' NT of the clone defined in Table 1) are synthesized and used to amplify the desired cDNA using the deposited cDNA plasmid

5 as a template. The polymerase chain reaction is carried out under routine conditions, for instance, in 25 ul of reaction mixture with 0.5 ug of the above cDNA template. A convenient reaction mixture is 1.5-5 mM MgCl₂, 0.01% (w/v) gelatin, 20 uM each of dATP, dCTP, dGTP, dTTP, 25 pmol of each primer and 0.25 Unit of Taq polymerase. Thirty five cycles of PCR (denaturation at 94 degree C for 1 min; annealing at 55
10 degree C for 1 min; elongation at 72 degree C for 1 min) are performed with a Perkin-Elmer Cetus automated thermal cycler. The amplified product is analyzed by agarose gel electrophoresis and the DNA band with expected molecular weight is excised and purified. The PCR product is verified to be the selected sequence by subcloning and sequencing the DNA product.

15 The polynucleotide(s) of the present invention, the polynucleotide encoding the polypeptide of the present invention, or the polypeptide encoded by the deposited clone may represent partial, or incomplete versions of the complete coding region (i.e., full-length gene). Several methods are known in the art for the identification of the 5' or 3' non-coding and/or coding portions of a gene which may not be present in
20 the deposited clone. The methods that follow are exemplary and should not be construed as limiting the scope of the invention. These methods include but are not limited to, filter probing, clone enrichment using specific probes, and protocols similar or identical to 5' and 3' "RACE" protocols that are well known in the art. For instance, a method similar to 5' RACE is available for generating the missing 5' end
25 of a desired full-length transcript. (Fromont-Racine et al., Nucleic Acids Res. 21(7):1683-1684 (1993)).

Briefly, a specific RNA oligonucleotide is ligated to the 5' ends of a population of RNA presumably containing full-length gene RNA transcripts. A primer set containing a primer specific to the ligated RNA oligonucleotide and a
30 primer specific to a known sequence of the gene of interest is used to PCR amplify the 5' portion of the desired full-length gene. This amplified product may then be sequenced and used to generate the full-length gene.

This above method starts with total RNA isolated from the desired source, although poly-A⁺ RNA can be used. The RNA preparation can then be treated with
35 phosphatase if necessary to eliminate 5' phosphate groups on degraded or damaged RNA that may interfere with the later RNA ligase step. The phosphatase should then

5 be inactivated and the RNA treated with tobacco acid pyrophosphatase in order to remove the cap structure present at the 5' ends of messenger RNAs. This reaction leaves a 5' phosphate group at the 5' end of the cap cleaved RNA which can then be ligated to an RNA oligonucleotide using T4 RNA ligase.

This modified RNA preparation is used as a template for first strand cDNA
10 synthesis using a gene specific oligonucleotide. The first strand synthesis reaction is used as a template for PCR amplification of the desired 5' end using a primer specific to the ligated RNA oligonucleotide and a primer specific to the known sequence of the gene of interest. The resultant product is then sequenced and analyzed to confirm that the 5' end sequence belongs to the desired gene. Moreover, it may be
15 advantageous to optimize the RACE protocol to increase the probability of isolating additional 5' or 3' coding or non-coding sequences. Various methods of optimizing a RACE protocol are known in the art, though a detailed description summarizing these methods can be found in B.C. Schaefer, *Anal. Biochem.*, 227:255-273, (1995).

An alternative method for carrying out 5' or 3' RACE for the identification of
20 coding or non-coding sequences is provided by Frohman, M.A., et al., *Proc.Nat'l.Acad.Sci.USA*, 85:8998-9002 (1988). Briefly, a cDNA clone missing either the 5' or 3' end can be reconstructed to include the absent base pairs extending to the translational start or stop codon, respectively. In some cases, cDNAs are missing the start of translation, therefore. The following briefly describes a modification of this
25 original 5' RACE procedure. Poly A⁺ or total RNAs reverse transcribed with Superscript II (Gibco/BRL) and an antisense or I complementary primer specific to the cDNA sequence. The primer is removed from the reaction with a Microcon Concentrator (Amicon). The first-strand cDNA is then tailed with dATP and terminal deoxynucleotide transferase (Gibco/BRL). Thus, an anchor sequence is produced
30 which is needed for PCR amplification. The second strand is synthesized from the dA-tail in PCR buffer, Taq DNA polymerase (Perkin-Elmer Cetus), an oligo-dT primer containing three adjacent restriction sites (XhoI, SalI and ClaI) at the 5' end and a primer containing just these restriction sites. This double-stranded cDNA is PCR amplified for 40 cycles with the same primers as well as a nested cDNA-specific
35 antisense primer. The PCR products are size-separated on an ethidium bromide-agarose gel and the region of gel containing cDNA products the predicted size of

5 missing protein-coding DNA is removed. cDNA is purified from the agarose with the Magic PCR Prep kit (Promega), restriction digested with XhoI or Sall, and ligated to a plasmid such as pBluescript SKII (Stratagene) at XhoI and EcoRV sites. This DNA is transformed into bacteria and the plasmid clones sequenced to identify the correct protein-coding inserts. Correct 5' ends are confirmed by comparing this sequence with
10 the putatively identified homologue and overlap with the partial cDNA clone. Similar methods known in the art and/or commercial kits are used to amplify and recover 3' ends.

Several quality-controlled kits are commercially available for purchase. Similar reagents and methods to those above are supplied in kit form from
15 Gibco/BRL for both 5' and 3' RACE for recovery of full length genes. A second kit is available from Clontech which is a modification of a related technique, SLIC (single-stranded ligation to single-stranded cDNA), developed by Dumas et al., Nucleic Acids Res., 19:5227-32(1991). The major differences in procedure are that the RNA is alkaline hydrolyzed after reverse transcription and RNA ligase is used to join a
20 restriction site-containing anchor primer to the first-strand cDNA. This obviates the necessity for the dA-tailing reaction which results in a polyT stretch that is difficult to sequence past.

An alternative to generating 5' or 3' cDNA from RNA is to use cDNA library double-stranded DNA. An asymmetric PCR-amplified antisense cDNA strand is
25 synthesized with an antisense cDNA-specific primer and a plasmid-anchored primer. These primers are removed and a symmetric PCR reaction is performed with a nested cDNA-specific antisense primer and the plasmid-anchored primer.

30 *RNA Ligase Protocol For Generating The 5' or 3' End Sequences To Obtain Full Length Genes*

Once a gene of interest is identified, several methods are available for the identification of the 5' or 3' portions of the gene which may not be present in the original cDNA plasmid. These methods include, but are not limited to, filter probing, clone enrichment using specific probes and protocols similar and identical to 5' and
35 3'RACE. While the full-length gene may be present in the library and can be identified by probing, a useful method for generating the 5' or 3' end is to use the

5 existing sequence information from the original cDNA to generate the missing information. A method similar to 5'RACE is available for generating the missing 5' end of a desired full-length gene. (This method was published by Fromont-Racine et al., Nucleic Acids Res., 21(7): 1683-1684 (1993)). Briefly, a specific RNA oligonucleotide is ligated to the 5' ends of a population of RNA presumably 30 containing full-length gene RNA transcript and a primer set containing a primer specific to the ligated RNA oligonucleotide and a primer specific to a known sequence of the gene of interest, is used to PCR amplify the 5' portion of the desired full length gene which may then be sequenced and used to generate the full length gene. This method starts with total RNA isolated from the desired source, poly A 15 RNA may be used but is not a prerequisite for this procedure. The RNA preparation may then be treated with phosphatase if necessary to eliminate 5' phosphate groups on degraded or damaged RNA which may interfere with the later RNA ligase step. The phosphatase if used is then inactivated and the RNA is treated with tobacco acid pyrophosphatase in order to remove the cap structure present at the 5' ends of 20 messenger RNAs. This reaction leaves a 5' phosphate group at the 5' end of the cap cleaved RNA which can then be ligated to an RNA oligonucleotide using T4 RNA ligase. This modified RNA preparation can then be used as a template for first strand cDNA synthesis using a gene specific oligonucleotide. The first strand synthesis reaction can then be used as a template for PCR amplification of the desired 5' end 25 using a primer specific to the ligated RNA oligonucleotide and a primer specific to the known sequence of the apoptosis related of interest. The resultant product is then sequenced and analyzed to confirm that the 5' end sequence belongs to the relevant apoptosis related.

30 **Example 12 - Tissue Distribution of Polypeptide.**

Tissue distribution of mRNA expression of polynucleotides of the present invention is determined using protocols for Northern blot analysis, described by, among others, Sambrook et al. For example, a cDNA probe produced by the method described in Example 11 is labeled with p32 using the rediprime™ DNA labeling 35 system (Amersham Life Science), according to manufacturer's instructions. After labeling, the probe is purified using CHROMA SPIN0-100 column (Clontech

5 Laboratories, Inc.) according to manufacturer's protocol number PT1200-1. The purified labeled probe is then used to examine various tissues for mRNA expression.

Tissue Northern blots containing the bound mRNA of various tissues are examined with the labeled probe using ExpressHyb™ hybridization solution (Clontech according to manufacturers protocol number PT1190-1. Northern blots
10 can be produced using various protocols well known in the art (e.g., Sambrook et al). Following hybridization and washing, the blots are mounted and exposed to film at – 70C overnight, and the films developed according to standard procedures.

Example 13 - Chromosomal Mapping of the Polynucleotides.

15 An oligonucleotide primer set is designed according to the sequence at the 5' end of SEQ ID NO:1, or SEQ ID NO:23. This primer preferably spans about 100 nucleotides. This primer set is then used in a polymerase chain reaction under the following set of conditions: 30 seconds, 95 degree C; 1 minute, 56 degree C; 1 minute, 70 degree C. This cycle is repeated 32 times followed by one 5 minute cycle at 70
20 degree C. Mammalian DNA, preferably human DNA, is used as template in addition to a somatic cell hybrid panel containing individual chromosomes or chromosome fragments (Bios, Inc). The reactions are analyzed on either 8% polyacrylamide gels or 3.5 % agarose gels. Chromosome mapping is determined by the presence of an approximately 100 bp PCR fragment in the particular somatic cell hybrid.

25

Example 14 - Bacterial Expression of a Polypeptide.

A polynucleotide encoding a polypeptide of the present invention is amplified using PCR oligonucleotide primers corresponding to the 5' and 3' ends of the DNA sequence, as outlined in Example 11, to synthesize insertion fragments. The primers
30 used to amplify the cDNA insert should preferably contain restriction sites, such as BamHI and XbaI, at the 5' end of the primers in order to clone the amplified product into the expression vector. For example, BamHI and XbaI correspond to the restriction enzyme sites on the bacterial expression vector pQE-9. (Qiagen, Inc., Chatsworth, CA). This plasmid vector encodes antibiotic resistance (Ampr), a
35 bacterial origin of replication (ori), an IPTG-regulatable promoter/operator (P/O), a

5 ribosome binding site (RBS), a 6-histidine tag (6-His), and restriction enzyme cloning sites.

The pQE-9 vector is digested with BamHI and XbaI and the amplified fragment is ligated into the pQE-9 vector maintaining the reading frame initiated at the bacterial RBS. The ligation mixture is then used to transform the E. coli strain
10 M15/rep4 (Qiagen, Inc.) which contains multiple copies of the plasmid pREP4, that expresses the lacI repressor and also confers kanamycin resistance (Kanr). Transformants are identified by their ability to grow on LB plates and ampicillin/kanamycin resistant colonies are selected. Plasmid DNA is isolated and confirmed by restriction analysis.

15 Clones containing the desired constructs are grown overnight (O/N) in liquid culture in LB media supplemented with both Amp (100 ug/ml) and Kan (25 ug/ml). The O/N culture is used to inoculate a large culture at a ratio of 1:100 to 1:250. The cells are grown to an optical density 600 (O.D.600) of between 0.4 and 0.6. IPTG (Isopropyl-B-D-thiogalactopyranoside) is then added to a final concentration of 1
20 mM. IPTG induces by inactivating the lacI repressor, clearing the P/O leading to increased gene expression.

Cells are grown for an extra 3 to 4 hours. Cells are then harvested by centrifugation (20 mins at 6000Xg). The cell pellet is solubilized in the chaotropic agent 6 Molar Guanidine HCl by stirring for 3-4 hours at 4 degree C. The cell debris
25 is removed by centrifugation, and the supernatant containing the polypeptide is loaded onto a nickel-nitrilo-tri-acetic acid ("Ni-NTA") affinity resin column (available from QIAGEN, Inc., supra). Proteins with a 6 x His tag bind to the Ni-NTA resin with high affinity and can be purified in a simple one-step procedure (for details see: The QIAexpressionist (1995) QIAGEN, Inc., supra).

30 Briefly, the supernatant is loaded onto the column in 6 M guanidine-HCl, pH 8, the column is first washed with 10 volumes of 6 M guanidine-HCl, pH 8, then washed with 10 volumes of 6 M guanidine-HCl pH 6, and finally the polypeptide is eluted with 6 M guanidine-HCl, pH 5.

The purified protein is then renatured by dialyzing it against phosphate-buffered saline (PBS) or 50 mM Na-acetate, pH 6 buffer plus 200 mM NaCl.
35 Alternatively, the protein can be successfully refolded while immobilized on the Ni-

5 NTA column. The recommended conditions are as follows: renature using a linear 6M-1M urea gradient in 500 mM NaCl, 20% glycerol, 20 mM Tris/HCl pH 7.4, containing protease inhibitors. The renaturation should be performed over a period of 1.5 hours or more. After renaturation the proteins are eluted by the addition of 250 mM imidazole. Imidazole is removed by a final dialyzing step against PBS or 50 mM
10 sodium acetate pH 6 buffer plus 200 mM NaCl. The purified protein is stored at 4 degree C or frozen at -80 degree C.

Example 15 - Purification of a Polypeptide from an Inclusion Body.

The following alternative method can be used to purify a polypeptide
15 expressed in E coli when it is present in the form of inclusion bodies. Unless otherwise specified, all of the following steps are conducted at 4-10 degree C.

Upon completion of the production phase of the E. coli fermentation, the cell culture is cooled to 4-10 degree C and the cells harvested by continuous centrifugation at 15,000 rpm (Heraeus Sepatech). On the basis of the expected yield
20 of protein per unit weight of cell paste and the amount of purified protein required, an appropriate amount of cell paste, by weight, is suspended in a buffer solution containing 100 mM Tris, 50 mM EDTA, pH 7.4. The cells are dispersed to a homogeneous suspension using a high shear mixer.

The cells are then lysed by passing the solution through a microfluidizer
25 (Microfluidics, Corp. or APV Gaulin, Inc.) twice at 4000-6000 psi. The homogenate is then mixed with NaCl solution to a final concentration of 0.5 M NaCl, followed by centrifugation at 7000 xg for 15 min. The resultant pellet is washed again using 0.5M NaCl, 100 mM Tris, 50 mM EDTA, pH 7.4.

The resulting washed inclusion bodies are solubilized with 1.5 M guanidine
30 hydrochloride (GuHCl) for 2-4 hours. After 7000 xg centrifugation for 15 min., the pellet is discarded and the polypeptide containing supernatant is incubated at 4 degree C overnight to allow further GuHCl extraction.

Following high speed centrifugation (30,000 xg) to remove insoluble particles, the GuHCl solubilized protein is refolded by quickly mixing the GuHCl extract with
35 20 volumes of buffer containing 50 mM sodium, pH 4.5, 150 mM NaCl, 2 mM EDTA

5 by vigorous stirring. The refolded diluted protein solution is kept at 4 degree C without mixing for 12 hours prior to further purification steps.

To clarify the refolded polypeptide solution, a previously prepared tangential filtration unit equipped with 0.16 um membrane filter with appropriate surface area (e.g., Filtron), equilibrated with 40 mM sodium acetate, pH 6.0 is employed. The
10 filtered sample is loaded onto a cation exchange resin (c.g., Poros HS-50, Perceptive Biosystems). The column is washed with 40 mM sodium acetate, pH 6.0 and eluted with 250 mM, 500 mM, 1000 mM, and 1500 mM NaCl in the same buffer, in a stepwise manner. The absorbance at 280 nm of the effluent is continuously monitored. Fractions are collected and further analyzed by SDS-PAGE.

15 Fractions containing the polypeptide are then pooled and mixed with 4 volumes of water. The diluted sample is then loaded onto a previously prepared set of tandem columns of strong anion (Poros HQ-50, Perceptive Biosystems) and weak anion (Poros CM-20, Perceptive Biosystems) exchange resins. The columns are equilibrated with 40 mM sodium acetate, pH 6.0. Both columns are washed with 40
20 mM sodium acetate, pH 6.0, 200 mM NaCl. The CM-20 column is then eluted using a 10 column volume linear gradient ranging from 0.2 M NaCl, 50 mM sodium acetate, pH 6.0 to 1.0 M NaCl, 50 mM sodium acetate, pH 6.5. Fractions are collected under constant A280 monitoring of the effluent. Fractions containing the polypeptide (determined, for instance, by 16% SDS-PAGE) are then pooled.

25 The resultant polypeptide should exhibit greater than 95% purity after the above refolding and purification steps. No major contaminant bands should be observed from Coomassie blue stained 16% SDS-PAGE gel when 5 ug of purified protein is loaded. The purified protein can also be tested for endotoxin/LPS contamination, and typically the LPS content is less than 0.1 ng/ml according to LAL
30 assays.

Example 16 - Cloning and Expression of a Polypeptide in a Baculovirus Expression System.

In this example, the plasmid shuttle vector pAc373 is used to insert a
35 polynucleotide into a baculovirus to express a polypeptide. A typical baculovirus expression vector contains the strong polyhedrin promoter of the Autographa

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5 californica nuclear polyhedrosis virus (AcMNPV) followed by convenient restriction sites, which may include, for example BamHI, Xba I and Asp718. The polyadenylation site of the simian virus 40 ("SV40") is often used for efficient polyadenylation. For easy selection of recombinant virus, the plasmid contains the
10 the same orientation, followed by the polyadenylation signal of the polyhedrin gene. The inserted genes are flanked on both sides by viral sequences for cell-mediated homologous recombination with wild-type viral DNA to generate a viable virus that express the cloned polynucleotide.

Many other baculovirus vectors can be used in place of the vector above, such
15 as pVL941 and pAcIM1, as one skilled in the art would readily appreciate, as long as the construct provides appropriately located signals for transcription, translation, secretion and the like, including a signal peptide and an in-frame AUG as required. Such vectors are described, for instance, in Luckow et al., Virology 170:31-39 (1989).

A polynucleotide encoding a polypeptide of the present invention is amplified
20 using PCR oligonucleotide primers corresponding to the 5' and 3' ends of the DNA sequence, as outlined in Example 11, to synthesize insertion fragments. The primers used to amplify the cDNA insert should preferably contain restriction sites at the 5' end of the primers in order to clone the amplified product into the expression vector. Specifically, the cDNA sequence contained in the deposited clone, including the AUG
25 initiation codon and the naturally associated leader sequence identified elsewhere herein (if applicable), is amplified using the PCR protocol described in Example 11. If the naturally occurring signal sequence is used to produce the protein, the vector used does not need a second signal peptide. Alternatively, the vector can be modified to include a baculovirus leader sequence, using the standard methods described in
30 Summers et al., "A Manual of Methods for Baculovirus Vectors and Insect Cell Culture Procedures," Texas Agricultural Experimental Station Bulletin No. 1555 (1987).

The amplified fragment is isolated from a 1% agarose gel using a commercially available kit ("GeneClean," BIO 101 Inc., La Jolla, Ca.). The fragment
35 then is digested with appropriate restriction enzymes and again purified on a 1% agarose gel.

5 The plasmid is digested with the corresponding restriction enzymes and optionally, can be dephosphorylated using calf intestinal phosphatase, using routine procedures known in the art. The DNA is then isolated from a 1% agarose gel using a commercially available kit ("GeneClean" BIO 101 Inc., La Jolla, Ca.).

10 The fragment and the dephosphorylated plasmid are ligated together with T4 DNA ligase. E. coli HB101 or other suitable E. coli hosts such as XL-1 Blue (Stratagene Cloning Systems, La Jolla, CA) cells are transformed with the ligation mixture and spread on culture plates. Bacteria containing the plasmid are identified by digesting DNA from individual colonies and analyzing the digestion product by gel electrophoresis. The sequence of the cloned fragment is confirmed by DNA
15 sequencing.

 Five ug of a plasmid containing the polynucleotide is co-transformed with 1.0 ug of a commercially available linearized baculovirus DNA ("BaculoGoldtm baculovirus DNA", Pharmingen, San Diego, CA), using the lipofection method described by Felgner et al., Proc. Natl. Acad. Sci. USA 84:7413-7417 (1987). One ug
20 of BaculoGoldtm virus DNA and 5ug of the plasmid are mixed in a sterile well of a microtiter plate containing 50ul of serum-free Grace's medium (Life Technologies Inc., Gaithersburg, MD). Afterwards, 10 ul Lipofectin plus 90 ul Grace's medium are added, mixed and incubated for 15 minutes at room temperature. Then the transfection mixture is added drop-wise to Sf9 insect cells (ATCC CRL 1711) seeded
25 in a 35 mm tissue culture plate with 1 ml Grace's medium without serum. The plate is then incubated for 5 hours at 27 degrees C. The transfection solution is then removed from the plate and 1 ml of Grace's insect medium supplemented with 10% fetal calf serum is added. Cultivation is then continued at 27 degrees C for four days.

 After four days the supernatant is collected and a plaque assay is performed, as
30 described by Summers and Smith, supra. An agarose gel with "Blue Gal" (Life Technologies Inc., Gaithersburg) is used to allow easy identification and isolation of gal-expressing clones, which produce blue-stained plaques. (A detailed description of a "plaque assay" of this type can also be found in the user's guide for insect cell culture and baculovirology distributed by Life Technologies Inc., Gaithersburg, page
35 9-10.) After appropriate incubation, blue stained plaques are picked with the tip of a micropipettor (e.g., Eppendorf). The agar containing the recombinant viruses is then

5 resuspended in a microcentrifuge tube containing 200 ul of Grace's medium and the suspension containing the recombinant baculovirus is used to infect Sf9 cells seeded in 35 mm dishes. Four days later the supernatants of these culture dishes are harvested and then they are stored at 4 degree C.

To verify the expression of the polypeptide, Sf9 cells are grown in Grace's
10 medium supplemented with 10% heat-inactivated FBS. The cells are infected with the recombinant baculovirus containing the polynucleotide at a multiplicity of infection ("MOI") of about 2. If radiolabeled proteins are desired, 6 hours later the medium is removed and is replaced with SF900 II medium minus methionine and cysteine (available from Life Technologies Inc., Rockville, MD). After 42 hours, 5 uCi of 35S-
15 methionine and 5 uCi 35S-cysteine (available from Amersham) are added. The cells are further incubated for 16 hours and then are harvested by centrifugation. The proteins in the supernatant as well as the intracellular proteins are analyzed by SDS-PAGE followed by autoradiography (if radiolabeled).

Microsequencing of the amino acid sequence of the amino terminus of
20 purified protein may be used to determine the amino terminal sequence of the produced protein.

Example 17 - Expression of the K+betaM4 or K+betaM5 Polypeptide in Mammalian Cells.

25 The polypeptide of the present invention can be expressed in a mammalian cell. A typical mammalian expression vector contains a promoter element, which mediates the initiation of transcription of mRNA, a protein coding sequence, and signals required for the termination of transcription and polyadenylation of the transcript. Additional elements include enhancers, Kozak sequences and intervening
30 sequences flanked by donor and acceptor sites for RNA splicing. Highly efficient transcription is achieved with the early and late promoters from SV40, the long terminal repeats (LTRs) from Retroviruses, e.g., RSV, HTLVI, HIVI and the early promoter of the cytomegalovirus (CMV). However, cellular elements can also be used (e.g., the human actin promoter).

35 Suitable expression vectors for use in practicing the present invention include, for example, vectors such as pSVL and pMSG (Pharmacia, Uppsala, Sweden),

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5 pRSVcat (ATCC 37152), pSV2dhfr (ATCC 37146), pBC12MI (ATCC 67109), pCMVSPORT 2.0, and pCMVSPORT 3.0. Mammalian host cells that could be used include, human Hela, 293, H9 and Jurkat cells, mouse NIH3T3 and C127 cells, Cos 1, Cos 7 and CV1, quail QC1-3 cells, mouse L cells and Chinese hamster ovary (CHO) cells.

10 Alternatively, the polypeptide can be expressed in stable cell lines containing the polynucleotide integrated into a chromosome. The co-transformation with a selectable marker such as dhfr, gpt, neomycin, hygromycin allows the identification and isolation of the transformed cells.

The transformed gene can also be amplified to express large amounts of the
15 encoded protein. The DHFR (dihydrofolate reductase) marker is useful in developing cell lines that carry several hundred or even several thousand copies of the gene of interest. (See, e.g., Alt, F. W., et al., J. Biol. Chem... 253:1357-1370 (1978); Hamlin, J. L. and Ma, C., Biochem. et Biophys. Acta, 1097:107-143 (1990); Page, M. J. and Sydenham, M. A., Biotechnology 9:64-68 (1991).) Another useful selection marker is
20 the enzyme glutamine synthase (GS) (Murphy et al., Biochem J. 227:277-279 (1991); Bebbington et al., Bio/Technology 10:169-175 (1992). Using these markers, the mammalian cells are grown in selective medium and the cells with the highest resistance are selected. These cell lines contain the amplified gene(s) integrated into a chromosome. Chinese hamster ovary (CHO) and NSO cells are often used for the
25 production of proteins.

A polynucleotide of the present invention is amplified according to the protocol outlined in herein. If the naturally occurring signal sequence is used to produce the protein, the vector does not need a second signal peptide. Alternatively, if the naturally occurring signal sequence is not used, the vector can be modified to
30 include a heterologous signal sequence. (See, e.g., WO 96/34891.) The amplified fragment is isolated from a 1% agarose gel using a commercially available kit ("GeneClean," BIO 101 Inc., La Jolla, Ca.). The fragment then is digested with appropriate restriction enzymes and again purified on a 1% agarose gel.

The amplified fragment is then digested with the same restriction enzyme and
35 purified on a 1% agarose gel. The isolated fragment and the dephosphorylated vector are then ligated with T4 DNA ligase. E. coli HB101 or XL-1 Blue cells are then

5 transformed and bacteria are identified that contain the fragment inserted into plasmid pC6 using, for instance, restriction enzyme analysis.

Chinese hamster ovary cells lacking an active DHFR gene is used for transformation. Five μ g of an expression plasmid is cotransformed with 0.5 μ g of the plasmid pSVneo using lipofectin (Felgner et al., supra). The plasmid pSV2-neo
10 contains a dominant selectable marker, the neo gene from Tn5 encoding an enzyme that confers resistance to a group of antibiotics including G418. The cells are seeded in alpha minus MEM supplemented with 1 mg/ml G418. After 2 days, the cells are trypsinized and seeded in hybridoma cloning plates (Greiner, Germany) in alpha minus MEM supplemented with 10, 25, or 50 ng/ml of methotrexate plus 1 mg/ml
15 G418. After about 10-14 days single clones are trypsinized and then seeded in 6-well petri dishes or 10 ml flasks using different concentrations of methotrexate (50 nM, 100 nM, 200 nM, 400 nM, 800 nM). Clones growing at the highest concentrations of methotrexate are then transferred to new 6-well plates containing even higher concentrations of methotrexate (1 μ M, 2 μ M, 5 μ M, 10 mM, 20 mM). The same
20 procedure is repeated until clones are obtained which grow at a concentration of 100 - 200 μ M. Expression of the desired gene product is analyzed, for instance, by SDS-PAGE and Western blot or by reversed phase HPLC analysis.

25 **Example 18 - Protein Fusions Between the K+betaM4 or K+betaM5 Polypeptide and Another Polypeptide.**

The polypeptides of the present invention are preferably fused to other proteins. These fusion proteins can be used for a variety of applications. For example, fusion of the present polypeptides to His-tag, HA-tag, protein A, IgG domains, albumin, and maltose binding protein facilitates purification. (See Example described
30 herein; see also EP A 394,827; Traunecker, et al., Nature 331:84-86 (1988).) Similarly, fusion to IgG-1, IgG-3, and albumin increases the half-life time in vivo. Nuclear localization signals fused to the polypeptides of the present invention can target the protein to a specific subcellular localization, while covalent heterodimer or homodimers can increase or decrease the activity of a fusion protein. Fusion proteins
35 can also create chimeric molecules having more than one function. Finally, fusion proteins can increase solubility and/or stability of the fused protein compared to the

5 non-fused protein. All of the types of fusion proteins described above can be made by modifying the following protocol, which outlines the fusion of a polypeptide to an IgG molecule.

Briefly, the human Fc portion of the IgG molecule can be PCR amplified, using primers that span the 5' and 3' ends of the sequence described below. These
10 primers also should have convenient restriction enzyme sites that will facilitate cloning into an expression vector, preferably a mammalian expression vector. Note that the polynucleotide is cloned without a stop codon, otherwise a fusion protein will not be produced.

The naturally occurring signal sequence may be used to produce the protein (if
15 applicable). Alternatively, if the naturally occurring signal sequence is not used, the vector can be modified to include a heterologous signal sequence. (See, e.g., WO 96/34891 and/or US Patent No. 6,066,781, supra.)

Human IgG Fc region:

20 GGGATCCGGAGCCCAAATCTTCTGACAAACTCACACATGCCCACC
GTGCCCAGCACCTGAATTCGAGGGTGCACCGTCAGTCTTCCTCTTCCCCC
AAAACCCAAGGACACCCTCATGATCTCCCGGACTCCTGAGGTACACATGCG
TGGTGGTGGACGTAAGCCACGAAGACCCTGAGGTCAAGTTCAACTGGTAC
GTGGACGGCGTGGAGGTGCATAATGCCAAGACAAAGCCGCGGGAGGAGC
25 AGTACAACAGCACGTACCGTGTGGTCAGCGTCCTCACCGTCCTGCACCAAG
GACTGGCTGAATGGCAAGGAGTACAAGTGCAAGGTCTCCAACAAAGCCCT
CCCAACCCCCATCGAGAAAACCATCTCCAAGCCAAAGGGCAGCCCCGAG
AACCACAGGTGTACACCCTGCCCCCATCCCGGGATGAGCTGACCAAGAAC
CAGGTCAGCCTGACCTGCCTGGTCAAAGGCTTCTATCCAAGCGACATCGC
30 CGTGGAGTGGGAGAGCAATGGGCAGCCGGAGAACAACACTACAAGACCACG
CCTCCCGTGCTGGACTCCGACGGCTCCTTCTTCCTCTACAGCAAGCTCACC
GTGGACAAGAGCAGGTGGCAGCAGGGGAACGTCTTCTCATGCTCCGTGAT
GCATGAGGCTCTGCACAACCACTACACGCAGAAGAGCCTCTCCCTGTCTC
CGGGTAAATGAGTGCGACGGCCGCGACTCTAGAGGAT (SEQ ID NO:7)

35

5 **Example 19 - Production of an Antibody Directed Against K+betaM4 or K+betaM5 Polypeptides.**

 The antibodies of the present invention can be prepared by a variety of methods. (See, Current Protocols, Chapter 2.) As one example of such methods, cells expressing a polypeptide of the present invention are administered to an animal to induce the production of sera containing polyclonal antibodies. In a preferred method, a preparation of the protein is prepared and purified to render it substantially free of natural contaminants. Such a preparation is then introduced into an animal in order to produce polyclonal antisera of greater specific activity.

 In the most preferred method, the antibodies of the present invention are monoclonal antibodies (or protein binding fragments thereof). Such monoclonal antibodies can be prepared using hybridoma technology. (Köhler et al., Nature 256:495 (1975); Köhler et al., Eur. J. Immunol. 6:511 (1976); Köhler et al., Eur. J. Immunol. 6:292 (1976); Hammerling et al., in: Monoclonal Antibodies and T-Cell Hybridomas, Elsevier, N.Y., pp. 563-681 (1981).) In general, such procedures involve immunizing an animal (preferably a mouse) with polypeptide or, more preferably, with a polypeptide-expressing cell. Such cells may be cultured in any suitable tissue culture medium; however, it is preferable to culture cells in Earle's modified Eagle's medium supplemented with 10% fetal bovine serum (inactivated at about 56 degrees C), and supplemented with about 10 g/l of nonessential amino acids, about 1,000 U/ml of penicillin, and about 100 ug/ml of streptomycin.

 The splenocytes of such mice are extracted and fused with a suitable myeloma cell line. Any suitable myeloma cell line may be employed in accordance with the present invention; however, it is preferable to employ the parent myeloma cell line (SP2O), available from the ATCC. After fusion, the resulting hybridoma cells are selectively maintained in HAT medium, and then cloned by limiting dilution as described by Wands et al. (Gastroenterology 80:225-232 (1981).) The hybridoma cells obtained through such a selection are then assayed to identify clones which secrete antibodies capable of binding the polypeptide.

 Alternatively, additional antibodies capable of binding to the polypeptide can be produced in a two-step procedure using anti-idiotypic antibodies. Such a method makes use of the fact that antibodies are themselves antigens, and therefore, it is

5 possible to obtain an antibody that binds to a second antibody. In accordance with this method, protein specific antibodies are used to immunize an animal, preferably a mouse. The splenocytes of such an animal are then used to produce hybridoma cells, and the hybridoma cells are screened to identify clones that produce an antibody
10 polypeptide. Such antibodies comprise anti-idiotypic antibodies to the protein-specific antibody and can be used to immunize an animal to induce formation of further protein-specific antibodies.

It will be appreciated that Fab and F(ab')₂ and other fragments of the antibodies of the present invention may be used according to the methods disclosed
15 herein. Such fragments are typically produced by proteolytic cleavage, using enzymes such as papain (to produce Fab fragments) or pepsin (to produce F(ab')₂ fragments). Alternatively, protein-binding fragments can be produced through the application of recombinant DNA technology or through synthetic chemistry.

For in vivo use of antibodies in humans, it may be preferable to use
20 "humanized" chimeric monoclonal antibodies. Such antibodies can be produced using genetic constructs derived from hybridoma cells producing the monoclonal antibodies described above. Methods for producing chimeric antibodies are known in the art. (See, for review, Morrison, Science 229:1202 (1985); Oi et al., BioTechniques 4:214 (1986); Cabilly et al., U.S. Patent No. 4,816,567; Taniguchi et al., EP 171496; Morrison et al., EP 173494; Neuberger et al., WO 8601533; Robinson et al., WO
25 8702671; Boulianne et al., Nature 312:643 (1984); Neuberger et al., Nature 314:268 (1985).)

Moreover, in another preferred method, the antibodies directed against the polypeptides of the present invention may be produced in plants. Specific methods are
30 disclosed in US Patent Nos. 5,959,177, and 6,080,560, which are hereby incorporated in their entirety herein. The methods not only describe methods of expressing antibodies, but also the means of assembling foreign multimeric proteins in plants (i.e., antibodies, etc.), and the subsequent secretion of such antibodies from the plant.

5

Example 20 - Alteration of Protein Glycosylation Sites to Enhance Characteristics of Polypeptides of the Invention.

Many eukaryotic cell surface and proteins are post-translationally processed to incorporate N-linked and O-linked carbohydrates (Kornfeld and Kornfeld (1985) Annu. Rev. Biochem. 54:631-64; Rademacher et al., (1988) Annu. Rev. Biochem. 57:785-838). Protein glycosylation is thought to serve a variety of functions including: augmentation of protein folding, inhibition of protein aggregation, regulation of intracellular trafficking to organelles, increasing resistance to proteolysis, modulation of protein antigenicity, and mediation of intercellular adhesion (Fieldler and Simons (1995) Cell, 81:309-312; Helenius (1994) Mol. Biol. Of the Cell 5:253-265; Olden et al., (1978) Cell, 13:461-473; Caton et al., (1982) Cell, 37:417-427; Alexamnder and Elder (1984), Science, 226:1328-1330; and Flack et al., (1994), J. Biol. Chem..., 269:14015-14020). In higher organisms, the nature and extent of glycosylation can markedly affect the circulating half-life and bio-availability of proteins by mechanisms involving receptor mediated uptake and clearance (Ashwell and Morrell, (1974), Adv. Enzymol., 41:99-128; Ashwell and Harford (1982), Ann. Rev. Biochem., 51:531-54). Receptor systems have been identified that are thought to play a major role in the clearance of serum proteins through recognition of various carbohydrate structures on the glycoproteins (Stockert (1995), Physiol. Rev., 75:591-609; Kery et al., (1992), Arch. Biochem. Biophys., 298:49-55). Thus, production strategies resulting in incomplete attachment of terminal sialic acid residues might provide a means of shortening the bioavailability and half-life of glycoproteins. Conversely, expression strategies resulting in saturation of terminal sialic acid attachment sites might lengthen protein bioavailability and half-life.

In the development of recombinant glycoproteins for use as pharmaceutical products, for example, it has been speculated that the pharmacodynamics of recombinant proteins can be modulated by the addition or deletion of glycosylation sites from a glycoproteins primary structure (Berman and Lasky (1985a) Trends in Biotechnol., 3:51-53). However, studies have reported that the deletion of N-linked glycosylation sites often impairs intracellular transport and results in the intracellular

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5 accumulation of glycosylation site variants (Machamer and Rose (1988), J. Biol. Chem., 263:5955-5960; Gallagher et al., (1992), J. Virology., 66:7136-7145; Collier et al., (1993), Biochem., 32:7818-7823; Claffey et al., (1995) Biochimica et Biophysica Acta, 1246:1-9; Dube et al., (1988), J. Biol. Chem... 263:17516-17521). While glycosylation site variants of proteins can be expressed intracellularly, it has
10 proved difficult to recover useful quantities from growth conditioned cell culture medium.

Moreover, it is unclear to what extent a glycosylation site in one species will be recognized by another species glycosylation machinery. Due to the importance of glycosylation in protein metabolism, particularly the secretion and/or expression of
15 the protein, whether a glycosylation signal is recognized may profoundly determine a proteins ability to be expressed, either endogenously or recombinantly, in another organism (i.e., expressing a human protein in E.coli, yeast, or viral organisms; or an E.coli, yeast, or viral protein in human, etc.). Thus, it may be desirable to add, delete, or modify a glycosylation site, and possibly add a glycosylation site of one species to
20 a protein of another species to improve the proteins functional, bioprocess purification, and/or structural characteristics (e.g., a polypeptide of the present invention).

A number of methods may be employed to identify the location of glycosylation sites within a protein. One preferred method is to run the translated
25 protein sequence through the PROSITE computer program (Swiss Institute of Bioinformatics). Once identified, the sites could be systematically deleted, or impaired, at the level of the DNA using mutagenesis methodology known in the art and available to the skilled artisan, Preferably using PCR-directed mutagenesis (See Maniatis, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press, Cold
30 Spring, NY (1982)). Similarly, glycosylation sites could be added, or modified at the level of the DNA using similar methods, preferably PCR methods (See, Maniatis, supra). The results of modifying the glycosylation sites for a particular protein (e.g., solubility, secretion potential, activity, aggregation, proteolytic resistance, etc.) could then be analyzed using methods know in the art.

35

5 **Example 21 - Method of Enhancing the Biological Activity/Functional Characteristics of Invention through Molecular Evolution.**

 Although many of the most biologically active proteins known are highly effective for their specified function in an organism, they often possess characteristics that make them undesirable for transgenic, therapeutic, and/or industrial applications. 10 Among these traits, a short physiological half-life is the most prominent problem, and is present either at the level of the protein, or the level of the proteins mRNA. The ability to extend the half-life, for example, would be particularly important for a proteins use in gene therapy, transgenic animal production, the bioprocess production and purification of the protein, and use of the protein as a chemical modulator among 15 others. Therefore, there is a need to identify novel variants of isolated proteins possessing characteristics which enhance their application as a therapeutic for treating diseases of animal origin, in addition to the proteins applicability to common industrial and pharmaceutical applications.

 Thus, one aspect of the present invention relates to the ability to enhance 20 specific characteristics of invention through directed molecular evolution. Such an enhancement may, in a non-limiting example, benefit the inventions utility as an essential component in a kit, the inventions physical attributes such as its solubility, structure, or codon optimization, the inventions specific biological activity, including any associated enzymatic activity, the proteins enzyme kinetics, the proteins K_i , K_{cat} , 25 K_m , V_{max} , K_d , protein-protein activity, protein-DNA binding activity, antagonist/inhibitory activity (including direct or indirect interaction), agonist activity (including direct or indirect interaction), the proteins antigenicity (e.g., where it would be desirable to either increase or decrease the antigenic potential of the protein), the immunogenicity of the protein, the ability of the protein to form dimers, trimers, or 30 multimers with either itself or other proteins, the antigenic efficacy of the invention, including its subsequent use a preventative treatment for disease or disease states, or as an effector for targeting diseased genes. Moreover, the ability to enhance specific characteristics of a protein may also be applicable to changing the characterized activity of an enzyme to an activity completely unrelated to its initially characterized 35 activity. Other desirable enhancements of the invention would be specific to each

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5 individual protein, and would thus be well known in the art and contemplated by the present invention.

For example, an engineered potassium channel beta subunit may have an increased ability to modulate potassium channel alpha subunits, and/or potassium channel activity, in general. Alternatively, an engineered potassium channel beta subunit may have altered specificity for associating with potassium channel alpha subunits. In yet another example, an engineered potassium channel beta subunit may be capable of associating with alpha subunits with less than all of the regulatory factors and/or conditions typically required for potassium channel beta subunit association (e.g., Ca⁺ binding, etc.). Such potassium channel beta subunits would be useful in screens to identify potassium channel beta subunit modulators, among other uses described herein.

Directed evolution is comprised of several steps. The first step is to establish a library of variants for the gene or protein of interest. The most important step is to then select for those variants that entail the activity you wish to identify. The design of the screen is essential since your screen should be selective enough to eliminate non-useful variants, but not so stringent as to eliminate all variants. The last step is then to repeat the above steps using the best variant from the previous screen. Each successive cycle, can then be tailored as necessary, such as increasing the stringency of the screen, for example.

Over the years, there have been a number of methods developed to introduce mutations into macromolecules. Some of these methods include, random mutagenesis, "error-prone" PCR, chemical mutagenesis, site-directed mutagenesis, and other methods well known in the art (for a comprehensive listing of current mutagenesis methods, see Maniatis, Molecular Cloning: A Laboratory Manual, Cold Spring Harbor Press, Cold Spring, NY (1982)). Typically, such methods have been used, for example, as tools for identifying the core functional region(s) of a protein or the function of specific domains of a protein (if a multi-domain protein). However, such methods have more recently been applied to the identification of macromolecule variants with specific or enhanced characteristics.

Random mutagenesis has been the most widely recognized method to date. Typically, this has been carried out either through the use of "error-prone" PCR (as

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5 described in Moore, J., et al, Nature Biotechnology 14:458, (1996), or through the application of randomized synthetic oligonucleotides corresponding to specific regions of interest (as described by Derbyshire, K.M. et al, Gene, 46:145-152, (1986), and Hill, DE, et al, Methods Enzymol., 55:559-568, (1987). Both approaches have limits to the level of mutagenesis that can be obtained. However, either approach
10 enables the investigator to effectively control the rate of mutagenesis. This is particularly important considering the fact that mutations beneficial to the activity of the enzyme are fairly rare. In fact, using too high a level of mutagenesis may counter or inhibit the desired benefit of a useful mutation.

While both of the aforementioned methods are effective for creating
15 randomized pools of macromolecule variants, a third method, termed "DNA Shuffling", or "sexual PCR" (WPC, Stemmer, PNAS, 91:10747, (1994)) has recently been elucidated. DNA shuffling has also been referred to as "directed molecular evolution", "exon-shuffling", "directed enzyme evolution", "in vitro evolution", and "artificial evolution". Such reference terms are known in the art and are encompassed
20 by the invention. This new, preferred, method apparently overcomes the limitations of the previous methods in that it not only propagates positive traits, but simultaneously eliminates negative traits in the resulting progeny.

DNA shuffling accomplishes this task by combining the principal of in vitro recombination, along with the method of "error-prone" PCR. In effect, you begin with
25 a randomly digested pool of small fragments of your gene, created by Dnase I digestion, and then introduce said random fragments into an "error-prone" PCR assembly reaction. During the PCR reaction, the randomly sized DNA fragments not only hybridize to their cognate strand, but also may hybridize to other DNA fragments corresponding to different regions of the polynucleotide of interest – regions not
30 typically accessible via hybridization of the entire polynucleotide. Moreover, since the PCR assembly reaction utilizes "error-prone" PCR reaction conditions, random mutations are introduced during the DNA synthesis step of the PCR reaction for all of the fragments -further diversifying the potential hybridization sites during the annealing step of the reaction.

5 A variety of reaction conditions could be utilized to carry-out the DNA shuffling reaction. However, specific reaction conditions for DNA shuffling are provided, for example, in PNAS, 91:10747, (1994). Briefly:

 Prepare the DNA substrate to be subjected to the DNA shuffling reaction. Preparation may be in the form of simply purifying the DNA from contaminating
10 cellular material, chemicals, buffers, oligonucleotide primers, deoxynucleotides, RNAs, etc., and may entail the use of DNA purification kits as those provided by Qiagen, Inc., or by the Promega, Corp., for example.

 Once the DNA substrate has been purified, it would be subjected to Dnase I digestion. About 2-4ug of the DNA substrate(s) would be digested with .0015 units of
15 Dnase I (Sigma) per ul in 100ul of 50mM Tris-HCL, pH 7.4/1mM MgCl₂ for 10-20 min. at room temperature. The resulting fragments of 10-50bp could then be purified by running them through a 2% low-melting point agarose gel by electrophoresis onto DE81 ion-exchange paper (Whatmann) or could be purified using Microcon concentrators (Amicon) of the appropriate molecular weight cutoff, or could use
20 oligonucleotide purification columns (Qiagen), in addition to other methods known in the art. If using DE81 ion-exchange paper, the 10-50bp fragments could be eluted from said paper using 1M NaCl, followed by ethanol precipitation.

 The resulting purified fragments would then be subjected to a PCR assembly reaction by re-suspension in a PCR mixture containing: 2mM of each dNTP, 2.2mM
25 MgCl₂, 50 mM KCl, 10mM Tris•HCL, pH 9.0, and 0.1% Triton X-100, at a final fragment concentration of 10-30ng/ul. No primers are added at this point. *Taq* DNA polymerase (Promega) would be used at 2.5 units per 100ul of reaction mixture. A PCR program of 94 C for 60s; 94 C for 30s, 50-55 C for 30s, and 72 C for 30s using 30-45 cycles, followed by 72 C for 5min using an MJ Research (Cambridge, MA)
30 PTC-150 thermocycler. After the assembly reaction is completed, a 1:40 dilution of the resulting primerless product would then be introduced into a PCR mixture (using the same buffer mixture used for the assembly reaction) containing 0.8um of each primer and subjecting this mixture to 15 cycles of PCR (using 94 C for 30s, 50 C for 30s, and 72 C for 30s). The referred primers would be primers corresponding to the
35 nucleic acid sequences of the polynucleotide(s) utilized in the shuffling reaction. Said primers could consist of modified nucleic acid base pairs using methods known in the

5 art and referred to else where herein, or could contain additional sequences (i.e., for adding restriction sites, mutating specific base-pairs, etc.).

The resulting shuffled, assembled, and amplified product can be purified using methods well known in the art (e.g., Qiagen PCR purification kits) and then subsequently cloned using appropriate restriction enzymes.

10 Although a number of variations of DNA shuffling have been published to date, such variations would be obvious to the skilled artisan and are encompassed by the invention. The DNA shuffling method can also be tailored to the desired level of mutagenesis using the methods described by Zhao, et al. (Nucl Acid Res., 25(6):1307-1308, (1997).

15 As described above, once the randomized pool has been created, it can then be subjected to a specific screen to identify the variant possessing the desired characteristic(s). Once the variant has been identified, DNA corresponding to the variant could then be used as the DNA substrate for initiating another round of DNA shuffling. This cycle of shuffling, selecting the optimized variant of interest, and then
20 re-shuffling, can be repeated until the ultimate variant is obtained. Examples of model screens applied to identify variants created using DNA shuffling technology may be found in the following publications: J. C., Moore, et al., J. Mol. Biol., 272:336-347, (1997), F.R., Cross, et al., Mol. Cell. Biol., 18:2923-2931, (1998), and A. Cramer, et al., Nat. Biotech., 15:436-438, (1997).

25 DNA shuffling has several advantages. First, it makes use of beneficial mutations. When combined with screening, DNA shuffling allows the discovery of the best mutational combinations and does not assume that the best combination contains all the mutations in a population. Secondly, recombination occurs simultaneously with point mutagenesis. An effect of forcing DNA polymerase to
30 synthesize full-length genes from the small fragment DNA pool is a background mutagenesis rate. In combination with a stringent selection method, enzymatic activity has been evolved up to 16000 fold increase over the wild-type form of the enzyme. In essence, the background mutagenesis yielded the genetic variability on which recombination acted to enhance the activity.

35 A third feature of recombination is that it can be used to remove deleterious mutations. As discussed above, during the process of the randomization, for every one

5 beneficial mutation, there may be at least one or more neutral or inhibitory mutations. Such mutations can be removed by including in the assembly reaction an excess of the wild-type random-size fragments, in addition to the random-size fragments of the selected mutant from the previous selection. During the next selection, some of the most active variants of the polynucleotide/polypeptide/enzyme, should have lost the
10 inhibitory mutations.

Finally, recombination enables parallel processing. This represents a significant advantage since there are likely multiple characteristics that would make a protein more desirable (e.g. solubility, activity, etc.). Since it is increasingly difficult to screen for more than one desirable trait at a time, other methods of molecular
15 evolution tend to be inhibitory. However, using recombination, it would be possible to combine the randomized fragments of the best representative variants for the various traits, and then select for multiple properties at once.

DNA shuffling can also be applied to the polynucleotides and polypeptides of the present invention to decrease their immunogenicity in a specified host. For
20 example, a particular variant of the present invention may be created and isolated using DNA shuffling technology. Such a variant may have all of the desired characteristics, though may be highly immunogenic in a host due to its novel intrinsic structure. Specifically, the desired characteristic may cause the polypeptide to have a non-native structure which could no longer be recognized as a “self” molecule, but
25 rather as a “foreign”, and thus activate a host immune response directed against the novel variant. Such a limitation can be overcome, for example, by including a copy of the gene sequence for a xenobiotic ortholog of the native protein in with the gene sequence of the novel variant gene in one or more cycles of DNA shuffling. The molar ratio of the ortholog and novel variant DNAs could be varied accordingly.
30 Ideally, the resulting hybrid variant identified would contain at least some of the coding sequence which enabled the xenobiotic protein to evade the host immune system, and additionally, the coding sequence of the original novel variant that provided the desired characteristics.

Likewise, the invention encompasses the application of DNA shuffling
35 technology to the evolution of polynucleotides and polypeptides of the invention, wherein one or more cycles of DNA shuffling include, in addition to the gene

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5 template DNA, oligonucleotides coding for known allelic sequences, optimized codon sequences, known variant sequences, known polynucleotide polymorphism sequences, known ortholog sequences, known homologue sequences, additional homologous sequences, additional non-homologous sequences, sequences from another species, and any number and combination of the above.

10 In addition to the described methods above, there are a number of related methods that may also be applicable, or desirable in certain cases. Representative among these are the methods discussed in PCT applications WO 98/31700, and WO 98/32845, which are hereby incorporated by reference. Furthermore, related methods can also be applied to the polynucleotide sequences of the present invention in order
15 to evolve invention for creating ideal variants for use in gene therapy, protein engineering, evolution of whole cells containing the variant, or in the evolution of entire enzyme pathways containing polynucleotides of the invention as described in PCT applications WO 98/13485, WO 98/13487, WO 98/27230, WO 98/31837, and Cramer, A., et al., Nat. Biotech., 15:436-438, (1997), respectively.

20 Additional methods of applying "DNA Shuffling" technology to the polynucleotides and polypeptides of the present invention, including their proposed applications, may be found in US Patent No. 5,605,793; PCT Application No. WO 95/22625; PCT Application No. WO 97/20078; PCT Application No. WO 97/35966; and PCT Application No. WO 98/42832; PCT Application No. WO 00/09727
25 specifically provides methods for applying DNA shuffling to the identification of herbicide selective crops which could be applied to the polynucleotides and polypeptides of the present invention; additionally, PCT Application No. WO 00/12680 provides methods and compositions for generating, modifying, adapting, and optimizing polynucleotide sequences that confer detectable phenotypic properties
30 on plant species; each of the above are hereby incorporated in their entirety herein for all purposes.

Example 22 - Method of Determining Alterations in a Gene Corresponding to a Polynucleotide

35 RNA isolated from entire families or individual patients presenting with a phenotype of interest (such as a disease) is be isolated. cDNA is then generated from

5 these RNA samples using protocols known in the art. (See, Sambrook.) The cDNA is then used as a template for PCR, employing primers surrounding regions of interest in SEQ ID NO:1, or SEQ ID NO:23. Suggested PCR conditions consist of 35 cycles at 95 degrees C for 30 seconds; 60-120 seconds at 52-58 degrees C; and 60-120 seconds at 70 degrees C, using buffer solutions described in Sidransky et al., Science 252:706
10 (1991).

PCR products are then sequenced using primers labeled at their 5' end with T4 polynucleotide kinase, employing SequiTherm Polymerase. (Epicentre Technologies). The intron-exon borders of selected exons is also determined and genomic PCR products analyzed to confirm the results. PCR products harboring suspected mutations
15 is then cloned and sequenced to validate the results of the direct sequencing.

PCR products is cloned into T-tailed vectors as described in Holton et al., Nucleic Acids Research, 19:1156 (1991) and sequenced with T7 polymerase (United States Biochemical). Affected individuals are identified by mutations not present in unaffected individuals.

20 Genomic rearrangements are also observed as a method of determining alterations in a gene corresponding to a polynucleotide. Genomic clones isolated according to Example 11 are nick-translated with digoxigenin deoxy-uridine 5'-triphosphate (Boehringer Mannheim), and FISH performed as described in Johnson et al., Methods Cell Biol. 35:73-99 (1991). Hybridization with the labeled probe is
25 carried out using a vast excess of human cot-1 DNA for specific hybridization to the corresponding genomic locus.

Chromosomes are counterstained with 4,6-diamino-2-phenylidole and propidium iodide, producing a combination of C- and R-bands. Aligned images for precise mapping are obtained using a triple-band filter set (Chroma Technology,
30 Brattleboro, VT) in combination with a cooled charge-coupled device camera (Photometrics, Tucson, AZ) and variable excitation wavelength filters. (Johnson et al., Genet. Anal. Tech. Appl., 8:75 (1991).) Image collection, analysis and chromosomal fractional length measurements are performed using the ISee Graphical Program System. (Inovision Corporation, Durham, NC.) Chromosome alterations of the
35 genomic region hybridized by the probe are identified as insertions, deletions, and translocations. These alterations are used as a diagnostic marker for an associated

5 disease.

Example 23 - Method of Detecting Abnormal Levels of a Polypeptide in a Biological Sample

10 A polypeptide of the present invention can be detected in a biological sample, and if an increased or decreased level of the polypeptide is detected, this polypeptide is a marker for a particular phenotype. Methods of detection are numerous, and thus, it is understood that one skilled in the art can modify the following assay to fit their particular needs.

15 For example, antibody-sandwich ELISAs are used to detect polypeptides in a sample, preferably a biological sample. Wells of a microtiter plate are coated with specific antibodies, at a final concentration of 0.2 to 10 ug/ml. The antibodies are either monoclonal or polyclonal and are produced by the method described elsewhere herein. The wells are blocked so that non-specific binding of the polypeptide to the well is reduced.

20 The coated wells are then incubated for > 2 hours at RT with a sample containing the polypeptide. Preferably, serial dilutions of the sample should be used to validate results. The plates are then washed three times with deionized or distilled water to remove unbounded polypeptide.

25 Next, 50 ul of specific antibody-alkaline phosphatase conjugate, at a concentration of 25-400 ng, is added and incubated for 2 hours at room temperature. The plates are again washed three times with deionized or distilled water to remove unbounded conjugate.

30 Add 75 ul of 4-methylumbelliferyl phosphate (MUP) or p-nitrophenyl phosphate (NPP) substrate solution to each well and incubate 1 hour at room temperature. Measure the reaction by a microtiter plate reader. Prepare a standard curve, using serial dilutions of a control sample, and plot polypeptide concentration on the X-axis (log scale) and fluorescence or absorbance of the Y-axis (linear scale). Interpolate the concentration of the polypeptide in the sample using the standard curve.

35

5 **Example 24 - Formulation**

The invention also provides methods of treatment and/or prevention diseases, disorders, and/or conditions (such as, for example, any one or more of the diseases or disorders disclosed herein) by administration to a subject of an effective amount of a Therapeutic. By therapeutic is meant a polynucleotides or polypeptides of the invention (including fragments and variants), agonists or antagonists thereof, and/or
10 antibodies thereto, in combination with a pharmaceutically acceptable carrier type (e.g., a sterile carrier).

The Therapeutic will be formulated and dosed in a fashion consistent with good medical practice, taking into account the clinical condition of the individual
15 patient (especially the side effects of treatment with the Therapeutic alone), the site of delivery, the method of administration, the scheduling of administration, and other factors known to practitioners. The "effective amount" for purposes herein is thus determined by such considerations.

As a general proposition, the total pharmaceutically effective amount of the
20 Therapeutic administered parenterally per dose will be in the range of about 1ug/kg/day to 10 mg/kg/day of patient body weight, although, as noted above, this will be subject to therapeutic discretion. More preferably, this dose is at least 0.01 mg/kg/day, and most preferably for humans between about 0.01 and 1 mg/kg/day for the hormone. If given continuously, the Therapeutic is typically administered at a
25 dose rate of about 1 ug/kg/hour to about 50 ug/kg/hour, either by 1-4 injections per day or by continuous subcutaneous infusions, for example, using a mini-pump. An intravenous bag solution may also be employed. The length of treatment needed to observe changes and the interval following treatment for responses to occur appears to vary depending on the desired effect.

30 Therapeutics can be administered orally, rectally, parenterally, intracisternally, intravaginally, intraperitoneally, topically (as by powders, ointments, gels, drops or transdermal patch), buccally, or as an oral or nasal spray. "Pharmaceutically acceptable carrier" refers to a non-toxic solid, semisolid or liquid filler, diluent, encapsulating material or formulation auxiliary of any. The term "parenteral" as used herein refers to
35 modes of administration which include intravenous, intramuscular, intraperitoneal, intrasternal, subcutaneous and intraarticular injection and infusion.

5 In yet an additional embodiment, the Therapeutics of the invention are delivered orally using the drug delivery technology described in U.S. Patent 6,258,789, which is hereby incorporated by reference herein.

Therapeutics of the invention are also suitably administered by sustained-release systems. Suitable examples of sustained-release Therapeutics are administered
10 orally, rectally, parenterally, intracisternally, intravaginally, intraperitoneally, topically (as by powders, ointments, gels, drops or transdermal patch), buccally, or as an oral or nasal spray. "Pharmaceutically acceptable carrier" refers to a non-toxic solid, semisolid or liquid filler, diluent, encapsulating material or formulation auxiliary of any type. The term "parenteral" as used herein refers to modes of
15 administration which include intravenous, intramuscular, intraperitoneal, intrasternal, subcutaneous and intraarticular injection and infusion.

Therapeutics of the invention may also be suitably administered by sustained-release systems. Suitable examples of sustained-release Therapeutics include suitable polymeric materials (such as, for example, semi-permeable polymer matrices in the
20 form of shaped articles, e.g., films, or microcapsules), suitable hydrophobic materials (for example as an emulsion in an acceptable oil) or ion exchange resins, and sparingly soluble derivatives (such as, for example, a sparingly soluble salt).

Sustained-release matrices include polylactides (U.S. Pat. No. 3,773,919, EP 58,481), copolymers of L-glutamic acid and gamma-ethyl-L-glutamate (Sidman et al.,
25 Biopolymers 22:547-556 (1983)), poly (2- hydroxyethyl methacrylate) (Langer et al., J. Biomed. Mater. Res. 15:167-277 (1981), and Langer, Chem. Tech. 12:98-105 (1982)), ethylene vinyl acetate (Langer et al., Id.) or poly-D- (-)-3-hydroxybutyric acid (EP 133,988).

Sustained-release Therapeutics also include liposomally entrapped
30 Therapeutics of the invention (see, generally, Langer, Science 249:1527-1533 (1990); Treat et al., in Liposomes in the Therapy of Infectious Disease and Cancer, Lopez-Berestein and Fidler (eds.), Liss, New York, pp. 317 -327 and 353-365 (1989)). Liposomes containing the Therapeutic are prepared by methods known per se: DE 3,218,121; Epstein et al., Proc. Natl. Acad. Sci. (USA) 82:3688-3692 (1985); Hwang
35 et al., Proc. Natl. Acad. Sci.(USA) 77:4030-4034 (1980); EP 52,322; EP 36,676; EP 88,046; EP 143,949; EP 142,641; Japanese Pat. Appl. 83-118008; U.S. Pat. Nos.

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5 4,485,045 and 4,544,545; and EP 102,324. Ordinarily, the liposomes are of the small (about 200-800 Angstroms) unilamellar type in which the lipid content is greater than about 30 mol. percent cholesterol, the selected proportion being adjusted for the optimal Therapeutic.

10 In yet an additional embodiment, the Therapeutics of the invention are delivered by way of a pump (see Langer, supra; Sefton, CRC Crit. Ref. Biomed. Eng. 14:201 (1987); Buchwald et al., Surgery 88:507 (1980); Saudek et al., N. Engl. J. Med. 321:574 (1989)).

Other controlled release systems are discussed in the review by Langer (Science 249:1527-1533 (1990)).

15 For parenteral administration, in one embodiment, the Therapeutic is formulated generally by mixing it at the desired degree of purity, in a unit dosage injectable form (solution, suspension, or emulsion), with a pharmaceutically acceptable carrier, i.e., one that is non-toxic to recipients at the dosages and concentrations employed and is compatible with other ingredients of the formulation. 20 For example, the formulation preferably does not include oxidizing agents and other compounds that are known to be deleterious to the Therapeutic.

Generally, the formulations are prepared by contacting the Therapeutic uniformly and intimately with liquid carriers or finely divided solid carriers or both. Then, if necessary, the product is shaped into the desired formulation. Preferably the 25 carrier is a parenteral carrier, more preferably a solution that is isotonic with the blood of the recipient. Examples of such carrier vehicles include water, saline, Ringer's solution, and dextrose solution. Non-aqueous vehicles such as fixed oils and ethyl oleate are also useful herein, as well as liposomes.

The carrier suitably contains minor amounts of additives such as substances 30 that enhance isotonicity and chemical stability. Such materials are non-toxic to recipients at the dosages and concentrations employed, and include buffers such as phosphate, citrate, succinate, acetic acid, and other organic acids or their salts; antioxidants such as ascorbic acid; low molecular weight (less than about ten residues) polypeptides, e.g., polyarginine or tripeptides; proteins, such as serum 35 albumin, gelatin, or immunoglobulins; hydrophilic polymers such as polyvinylpyrrolidone; amino acids, such as glycine, glutamic acid, aspartic acid, or

5 arginine; monosaccharides, disaccharides, and other carbohydrates including cellulose or its derivatives, glucose, mannose, or dextrans; chelating agents such as EDTA; sugar alcohols such as mannitol or sorbitol; counterions such as sodium; and/or nonionic surfactants such as polysorbates, poloxamers, or PEG.

The Therapeutic will typically be formulated in such vehicles at a
10 concentration of about 0.1 mg/ml to 100 mg/ml, preferably 1-10 mg/ml, at a pH of about 3 to 8. It will be understood that the use of certain of the foregoing excipients, carriers, or stabilizers will result in the formation of polypeptide salts.

Any pharmaceutical used for therapeutic administration can be sterile. Sterility is readily accomplished by filtration through sterile filtration membranes (e.g., 0.2
15 micron membranes). Therapeutics generally are placed into a container having a sterile access port, for example, an intravenous solution bag or vial having a stopper pierceable by a hypodermic injection needle.

Therapeutics ordinarily will be stored in unit or multi-dose containers, for example, sealed ampoules or vials, as an aqueous solution or as a lyophilized
20 formulation for reconstitution. As an example of a lyophilized formulation, 10-ml vials are filled with 5 ml of sterile-filtered 1% (w/v) aqueous Therapeutic solution, and the resulting mixture is lyophilized. The infusion solution is prepared by reconstituting the lyophilized Therapeutic using bacteriostatic Water-for-Injection.

The invention also provides a pharmaceutical pack or kit comprising one or
25 more containers filled with one or more of the ingredients of the Therapeutics of the invention. Associated with such container(s) can be a notice in the form prescribed by a governmental agency regulating the manufacture, use or sale of pharmaceuticals or biological products, which notice reflects approval by the agency of manufacture, use or sale for human administration. In addition, the Therapeutics may be employed in
30 conjunction with other therapeutic compounds.

The Therapeutics of the invention may be administered alone or in combination with adjuvants. Adjuvants that may be administered with the Therapeutics of the invention include, but are not limited to, alum, alum plus deoxycholate (ImmunoAg), MTP-PE (Biocine Corp.), QS21 (Genentech, Inc.), BCG,
35 and MPL. In a specific embodiment, Therapeutics of the invention are administered in combination with alum. In another specific embodiment, Therapeutics of the

5 invention are administered in combination with QS-21. Further adjuvants that may be administered with the Therapeutics of the invention include, but are not limited to, Monophosphoryl lipid immunomodulator, AdjuVax 100a, QS-21, QS-18, CRL1005, Aluminum salts, MF-59, and Virosomal adjuvant technology. Vaccines that may be administered with the Therapeutics of the invention include, but are not limited to, 10 vaccines directed toward protection against MMR (measles, mumps, rubella), polio, varicella, tetanus/diphtheria, hepatitis A, hepatitis B, haemophilus influenzae B, whooping cough, pneumonia, influenza, Lyme's Disease, rotavirus, cholera, yellow fever, Japanese encephalitis, poliomyelitis, rabies, typhoid fever, and pertussis. Combinations may be administered either concomitantly, e.g., as an admixture, separately but simultaneously or concurrently; or sequentially. This includes 15 presentations in which the combined agents are administered together as a therapeutic mixture, and also procedures in which the combined agents are administered separately but simultaneously, e.g., as through separate intravenous lines into the same individual. Administration "in combination" further includes the separate administration of one of the compounds or agents given first, followed by the second. 20

The Therapeutics of the invention may be administered alone or in combination with other therapeutic agents. Therapeutic agents that may be administered in combination with the Therapeutics of the invention, include but not limited to, other members of the TNF family, chemotherapeutic agents, antibiotics, 25 steroidal and non-steroidal anti-inflammatories, conventional immunotherapeutic agents, cytokines and/or growth factors. Combinations may be administered either concomitantly, e.g., as an admixture, separately but simultaneously or concurrently; or sequentially. This includes presentations in which the combined agents are administered together as a therapeutic mixture, and also procedures in which the combined agents are administered separately but simultaneously, e.g., as through 30 separate intravenous lines into the same individual. Administration "in combination" further includes the separate administration of one of the compounds or agents given first, followed by the second.

In one embodiment, the Therapeutics of the invention are administered in combination with members of the TNF family. TNF, TNF-related or TNF-like 35 molecules that may be administered with the Therapeutics of the invention include,

5 but are not limited to, soluble forms of TNF-alpha, lymphotoxin-alpha (LT-alpha, also known as TNF-beta), LT-beta (found in complex heterotrimer LT-alpha2-beta), OPGL, FasL, CD27L, CD30L, CD40L, 4-1BBL, DcR3, OX40L, TNF-gamma (International Publication No. WO 96/14328), AIM-I (International Publication No. WO 97/33899), endokine-alpha (International Publication No. WO 98/07880), TR6
10 (International Publication No. WO 98/30694), OPG, and neutrokin-alpha (International Publication No. WO 98/18921, OX40, and nerve growth factor (NGF), and soluble forms of Fas, CD30, CD27, CD40 and 4-1BB, TR2 (International Publication No. WO 96/34095), DR3 (International Publication No. WO 97/33904), DR4 (International Publication No. WO 98/32856), TR5 (International Publication
15 No. WO 98/30693), TR6 (International Publication No. WO 98/30694), TR7 (International Publication No. WO 98/41629), TRANK, TR9 (International Publication No. WO 98/56892), TR10 (International Publication No. WO 98/54202), 312C2 (International Publication No. WO 98/06842), and TR12, and soluble forms CD154, CD70, and CD153.

20 In certain embodiments, Therapeutics of the invention are administered in combination with antiretroviral agents, nucleoside reverse transcriptase inhibitors, non-nucleoside reverse transcriptase inhibitors, and/or protease inhibitors. Nucleoside reverse transcriptase inhibitors that may be administered in combination with the Therapeutics of the invention, include, but are not limited to, RETROVIR
25 (zidovudine/AZT), VIDEX (didanosine/ddI), HIVID (zalcitabine/ddC), ZERIT (stavudine/d4T), EPIVIR (lamivudine/3TC), and COMBIVIR (zidovudine/lamivudine). Non-nucleoside reverse transcriptase inhibitors that may be administered in combination with the Therapeutics of the invention, include, but are not limited to, VIRAMUNE (nevirapine), RESCRIPTOR (delavirdine), and
30 SUSTIVA (efavirenz). Protease inhibitors that may be administered in combination with the Therapeutics of the invention, include, but are not limited to, CRIVAN (indinavir), NORVIR (ritonavir), INVIRASE (saquinavir), and VIRACEPT (nelfinavir). In a specific embodiment, antiretroviral agents, nucleoside reverse transcriptase inhibitors, non-nucleoside reverse transcriptase inhibitors, and/or
35 protease inhibitors may be used in any combination with Therapeutics of the invention to treat AIDS and/or to prevent or treat HIV infection.

5 In other embodiments, Therapeutics of the invention may be administered in combination with anti-opportunistic infection agents. Anti-opportunistic agents that may be administered in combination with the Therapeutics of the invention, include, but are not limited to, TRIMETHOPRIM-SULFAMETHOXAZOLE, DAPSONE, PENTAMIDINE, ATOVAQUONE, ISONIAZID, RIFAMPIN, PYRAZINAMIDE, 10 ETHAMBUTOL, RIFABUTIN, CLARITHROMYCIN, AZITHROMYCIN, GANCICLOVIR, FOSCARNET, CIDOFOVIR, FLUCONAZOLE, ITRACONAZOLE, KETOCONAZOLE, ACYCLOVIR, FAMCICOLVIR, PYRIMETHAMINE, LEUCOVORIN, NEUPOGEN (filgrastim/G-CSF), and LEUKINE (sargramostim/GM-CSF). In a specific embodiment, Therapeutics of the invention are used in any combination with TRIMETHOPRIM-SULFAMETHOXAZOLE, DAPSONE, PENTAMIDINE, and/or ATOVAQUONE to prophylactically treat or prevent an opportunistic *Pneumocystis carinii* pneumonia infection. In another specific embodiment, Therapeutics of the invention are used in any combination with ISONIAZID, RIFAMPIN, PYRAZINAMIDE, and/or 20 ETHAMBUTOL to prophylactically treat or prevent an opportunistic *Mycobacterium avium* complex infection. In another specific embodiment, Therapeutics of the invention are used in any combination with RIFABUTIN, CLARITHROMYCIN, and/or AZITHROMYCIN to prophylactically treat or prevent an opportunistic *Mycobacterium tuberculosis* infection. In another specific embodiment, Therapeutics of the invention are used in any combination with GANCICLOVIR, FOSCARNET, and/or CIDOFOVIR to prophylactically treat or prevent an opportunistic cytomegalovirus infection. In another specific embodiment, Therapeutics of the invention are used in any combination with FLUCONAZOLE, ITRACONAZOLE, and/or KETOCONAZOLE to prophylactically treat or prevent an opportunistic fungal 25 infection. In another specific embodiment, Therapeutics of the invention are used in any combination with ACYCLOVIR and/or FAMCICOLVIR to prophylactically treat or prevent an opportunistic herpes simplex virus type I and/or type II infection. In another specific embodiment, Therapeutics of the invention are used in any combination with PYRIMETHAMINE and/or LEUCOVORIN to prophylactically 30 treat or prevent an opportunistic *Toxoplasma gondii* infection. In another specific embodiment, Therapeutics of the invention are used in any combination with

5 LEUCOVORIN and/or NEUPOGEN to prophylactically treat or prevent an opportunistic bacterial infection.

In a further embodiment, the Therapeutics of the invention are administered in combination with an antiviral agent. Antiviral agents that may be administered with the Therapeutics of the invention include, but are not limited to, acyclovir, ribavirin,
10 amantadine, and remantidine.

In a further embodiment, the Therapeutics of the invention are administered in combination with an antibiotic agent. Antibiotic agents that may be administered with the Therapeutics of the invention include, but are not limited to, amoxicillin, beta-lactamases, aminoglycosides, beta-lactam (glycopeptide), beta-lactamases,
15 Clindamycin, chloramphenicol, cephalosporins, ciprofloxacin, ciprofloxacin, erythromycin, fluoroquinolones, macrolides, metronidazole, penicillins, quinolones, rifampin, streptomycin, sulfonamide, tetracyclines, trimethoprim, trimethoprim-sulfamthoxazole, and vancomycin.

Conventional nonspecific immunosuppressive agents, that may be
20 administered in combination with the Therapeutics of the invention include, but are not limited to, steroids, cyclosporine, cyclosporine analogs, cyclophosphamide methylprednisone, prednisone, azathioprine, FK-506, 15-deoxyspergualin, and other immunosuppressive agents that act by suppressing the function of responding T cells.

In specific embodiments, Therapeutics of the invention are administered in
25 combination with immunosuppressants. Immunosuppressants preparations that may be administered with the Therapeutics of the invention include, but are not limited to, ORTHOCLONE (OKT3), SANDIMMUNE/NEORAL/SANGDYA (cyclosporin), PROGRAF (tacrolimus), CELLCEPT (mycophenolate), Azathioprine, glucocorticosteroids, and RAPAMUNE (sirolimus). In a specific embodiment,
30 immunosuppressants may be used to prevent rejection of organ or bone marrow transplantation.

In an additional embodiment, Therapeutics of the invention are administered alone or in combination with one or more intravenous immune globulin preparations. Intravenous immune globulin preparations that may be administered with the
35 Therapeutics of the invention include, but not limited to, GAMMAR, IVEEGAM, SANDOGLOBULIN, GAMMAGARD S/D, and GAMIMUNE. In a specific

5 embodiment, Therapeutics of the invention are administered in combination with intravenous immune globulin preparations in transplantation therapy (e.g., bone marrow transplant).

 In an additional embodiment, the Therapeutics of the invention are administered alone or in combination with an anti-inflammatory agent. Anti-inflammatory agents that may be administered with the Therapeutics of the invention include, but are not limited to, glucocorticoids and the nonsteroidal anti-inflammatories, aminoarylcarboxylic acid derivatives, arylacetic acid derivatives, arylbutyric acid derivatives, arylcarboxylic acids, arylpropionic acid derivatives, pyrazoles, pyrazolones, salicylic acid derivatives, thiazinecarboxamides, e-
15 acetamidocaproic acid, S-adenosylmethionine, 3-amino-4-hydroxybutyric acid, amixetrine, bendazac, benzydamine, bucolome, difenpiramide, ditazol, emorfazone, guaiazulene, nabumetone, nimesulide, orgotein, oxaceprol, paranyline, perisoxal, pifoxime, proquazone, proxazole, and tenidap.

 In another embodiment, compositions of the invention are administered in combination with a chemotherapeutic agent. Chemotherapeutic agents that may be administered with the Therapeutics of the invention include, but are not limited to, antibiotic derivatives (e.g., doxorubicin, bleomycin, daunorubicin, and dactinomycin); antiestrogens (e.g., tamoxifen); antimetabolites (e.g., fluorouracil, 5-FU, methotrexate, floxuridine, interferon alpha-2b, glutamic acid, plicamycin, mercaptopurine, and 6-thioguanine); cytotoxic agents (e.g., carmustine, BCNU, lomustine, CCNU, cytosine arabinoside, cyclophosphamide, estramustine, hydroxyurea, procarbazine, mitomycin, busulfan, cis-platin, and vincristine sulfate); hormones (e.g., medroxyprogesterone, estramustine phosphate sodium, ethinyl estradiol, estradiol, megestrol acetate, methyltestosterone, diethylstilbestrol
25 diphosphate, chlorotrianisene, and testolactone); nitrogen mustard derivatives (e.g., mephallen, chorambucil, mechlorethamine (nitrogen mustard) and thiotepa); steroids and combinations (e.g., bethamethasone sodium phosphate); and others (e.g., dicarbazine, asparaginase, mitotane, vincristine sulfate, vinblastine sulfate, and etoposide).

35 In a specific embodiment, Therapeutics of the invention are administered in combination with CHOP (cyclophosphamide, doxorubicin, vincristine, and

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5 prednisone) or any combination of the components of CHOP. In another embodiment, Therapeutics of the invention are administered in combination with Rituximab. In a further embodiment, Therapeutics of the invention are administered with Rituxmab and CHOP, or Rituxmab and any combination of the components of CHOP.

10 In an additional embodiment, the Therapeutics of the invention are administered in combination with cytokines. Cytokines that may be administered with the Therapeutics of the invention include, but are not limited to, IL2, IL3, IL4, IL5, IL6, IL7, IL10, IL12, IL13, IL15, anti-CD40, CD40L, IFN-gamma and TNF-alpha. In another embodiment, Therapeutics of the invention may be administered with any interleukin, including, but not limited to, IL-1alpha, IL-1beta, IL-2, IL-3, IL-4, IL-5,
15 IL-6, IL-7, IL-8, IL-9, IL-10, IL-11, IL-12, IL-13, IL-14, IL-15, IL-16, IL-17, IL-18, IL-19, IL-20, and IL-21.

In an additional embodiment, the Therapeutics of the invention are administered in combination with angiogenic proteins. Angiogenic proteins that may be administered with the Therapeutics of the invention include, but are not limited to,
20 Glioma Derived Growth Factor (GDGF), as disclosed in European Patent Number EP-399816; Platelet Derived Growth Factor-A (PDGF-A), as disclosed in European Patent Number EP-682110; Platelet Derived Growth Factor-B (PDGF-B), as disclosed in European Patent Number EP-282317; Placental Growth Factor (PIGF), as disclosed in International Publication Number WO 92/06194; Placental Growth
25 Factor-2 (PIGF-2), as disclosed in Hauser et al., Growth Factors, 4:259-268 (1993); Vascular Endothelial Growth Factor (VEGF), as disclosed in International Publication Number WO 90/13649; Vascular Endothelial Growth Factor-A (VEGF-A), as disclosed in European Patent Number EP-506477; Vascular Endothelial Growth Factor-2 (VEGF-2), as disclosed in International Publication Number WO 96/39515;
30 Vascular Endothelial Growth Factor B (VEGF-3); Vascular Endothelial Growth Factor B-186 (VEGF-B186), as disclosed in International Publication Number WO 96/26736; Vascular Endothelial Growth Factor-D (VEGF-D), as disclosed in International Publication Number WO 98/02543; Vascular Endothelial Growth Factor-D (VEGF-D), as disclosed in International Publication Number WO 98/07832;
35 and Vascular Endothelial Growth Factor-E (VEGF-E), as disclosed in German Patent Number DE19639601. The above mentioned references are incorporated herein by

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5 reference herein.

In an additional embodiment, the Therapeutics of the invention are administered in combination with hematopoietic growth factors. Hematopoietic growth factors that may be administered with the Therapeutics of the invention include, but are not limited to, LEUKINE (SARGRAMOSTIM) and NEUPOGEN
10 (FILGRASTIM).

In an additional embodiment, the Therapeutics of the invention are administered in combination with Fibroblast Growth Factors. Fibroblast Growth Factors that may be administered with the Therapeutics of the invention include, but are not limited to, FGF-1, FGF-2, FGF-3, FGF-4, FGF-5, FGF-6, FGF-7, FGF-8,
15 FGF-9, FGF-10, FGF-11, FGF-12, FGF-13, FGF-14, and FGF-15.

In a specific embodiment, formulations of the present invention may further comprise antagonists of P-glycoprotein (also referred to as the multiresistance protein, or PGP), including antagonists of its encoding polynucleotides (e.g., antisense oligonucleotides, ribozymes, zinc-finger proteins, etc.). P-glycoprotein is well known
20 for decreasing the efficacy of various drug administrations due to its ability to export intracellular levels of absorbed drug to the cell exterior. While this activity has been particularly pronounced in cancer cells in response to the administration of chemotherapy regimens, a variety of other cell types and the administration of other drug classes have been noted (e.g., T-cells and anti-HIV drugs). In fact, certain
25 mutations in the PGP gene significantly reduces PGP function, making it less able to force drugs out of cells. People who have two versions of the mutated gene--one inherited from each parent--have more than four times less PGP than those with two normal versions of the gene. People may also have one normal gene and one mutated one. Certain ethnic populations have increased incidence of such PGP mutations.
30 Among individuals from Ghana, Kenya, the Sudan, as well as African Americans, frequency of the normal gene ranged from 73% to 84%. In contrast, the frequency was 34% to 59% among British whites, Portuguese, Southwest Asian, Chinese, Filipino and Saudi populations. As a result, certain ethnic populations may require increased administration of PGP antagonist in the formulation of the present invention
35 to arrive at the an efficacious dose of the therapeutic (e.g., those from African descent). Conversely, certain ethnic populations, particularly those having increased

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5 frequency of the mutated PGP (e.g., of Caucasian descent, or non-African descent) may require less pharmaceutical compositions in the formulation due to an effective increase in efficacy of such compositions as a result of the increased effective absorption (e.g., less PGP activity) of said composition.

Moreover, in another specific embodiment, formulations of the present
 10 invention may further comprise antagonists of OATP2 (also referred to as the multiresistance protein, or MRP2), including antagonists of its encoding polynucleotides (e.g., antisense oligonucleotides, ribozymes, zinc-finger proteins, etc.). The invention also further comprises any additional antagonists known to inhibit proteins thought to be attributable to a multidrug resistant phenotype in proliferating
 15 cells.

In additional embodiments, the Therapeutics of the invention are administered in combination with other therapeutic or prophylactic regimens, such as, for example, radiation therapy.

20 **Example 25 - Method of Treating Decreased Levels of the Polypeptide**

The present invention relates to a method for treating an individual in need of an increased level of a polypeptide of the invention in the body comprising administering to such an individual a composition comprising a therapeutically effective amount of an agonist of the invention (including polypeptides of the
 25 invention). Moreover, it will be appreciated that conditions caused by a decrease in the standard or normal expression level of a secreted protein in an individual can be treated by administering the polypeptide of the present invention, preferably in the secreted form. Thus, the invention also provides a method of treatment of an individual in need of an increased level of the polypeptide comprising administering
 30 to such an individual a Therapeutic comprising an amount of the polypeptide to increase the activity level of the polypeptide in such an individual.

For example, a patient with decreased levels of a polypeptide receives a daily dose 0.1-100 ug/kg of the polypeptide for six consecutive days. Preferably, the polypeptide is in the secreted form. The exact details of the dosing scheme, based on
 35 administration and formulation, are provided herein.

5 **Example 26 - Method of Treating Increased Levels of the Polypeptide**

 The present invention also relates to a method of treating an individual in need
of a decreased level of a polypeptide of the invention in the body comprising
administering to such an individual a composition comprising a therapeutically
effective amount of an antagonist of the invention (including polypeptides and
10 antibodies of the invention).

 In one example, antisense technology is used to inhibit production of a
polypeptide of the present invention. This technology is one example of a method of
decreasing levels of a polypeptide, preferably a secreted form, due to a variety of
etiologies, such as cancer. For example, a patient diagnosed with abnormally
15 increased levels of a polypeptide is administered intravenously antisense
polynucleotides at 0.5, 1.0, 1.5, 2.0 and 3.0 mg/kg day for 21 days. This treatment is
repeated after a 7-day rest period if the treatment was well tolerated. The formulation
of the antisense polynucleotide is provided herein.

20 **Example 27 - Method of Treatment Using Gene Therapy-Ex Vivo**

 One method of gene therapy transplants fibroblasts, which are capable of
expressing a polypeptide, onto a patient. Generally, fibroblasts are obtained from a
subject by skin biopsy. The resulting tissue is placed in tissue-culture medium and
separated into small pieces. Small chunks of the tissue are placed on a wet surface of
25 a tissue culture flask, approximately ten pieces are placed in each flask. The flask is
turned upside down, closed tight and left at room temperature over night. After 24
hours at room temperature, the flask is inverted and the chunks of tissue remain fixed
to the bottom of the flask and fresh media (e.g., Ham's F12 media, with 10% FBS,
penicillin and streptomycin) is added. The flasks are then incubated at 37 degree C for
30 approximately one week.

 At this time, fresh media is added and subsequently changed every several
days. After an additional two weeks in culture, a monolayer of fibroblasts emerge.
The monolayer is trypsinized and scaled into larger flasks.

 pMV-7 (Kirschmeier, P.T. et al., DNA, 7:219-25 (1988)), flanked by the long
35 terminal repeats of the Moloney murine sarcoma virus, is digested with EcoRI and
HindIII and subsequently treated with calf intestinal phosphatase. The linear vector is

5 fractionated on agarose gel and purified, using glass beads.

The cDNA encoding a polypeptide of the present invention can be amplified using PCR primers which correspond to the 5' and 3' end sequences respectively as set forth in Example 11 using primers and having appropriate restriction sites and initiation/stop codons, if necessary. Preferably, the 5' primer contains an EcoRI site and the 3' primer includes a HindIII site. Equal quantities of the Moloney murine sarcoma virus linear backbone and the amplified EcoRI and HindIII fragment are added together, in the presence of T4 DNA ligase. The resulting mixture is maintained under conditions appropriate for ligation of the two fragments. The ligation mixture is then used to transform bacteria HB101, which are then plated onto agar containing kanamycin for the purpose of confirming that the vector has the gene of interest properly inserted.

The amphotropic pA317 or GP+am12 packaging cells are grown in tissue culture to confluent density in Dulbecco's Modified Eagles Medium (DMEM) with 10% calf serum (CS), penicillin and streptomycin. The MSV vector containing the gene is then added to the media and the packaging cells transduced with the vector. The packaging cells now produce infectious viral particles containing the gene (the packaging cells are now referred to as producer cells).

Fresh media is added to the transduced producer cells, and subsequently, the media is harvested from a 10 cm plate of confluent producer cells. The spent media, containing the infectious viral particles, is filtered through a millipore filter to remove detached producer cells and this media is then used to infect fibroblast cells. Media is removed from a sub-confluent plate of fibroblasts and quickly replaced with the media from the producer cells. This media is removed and replaced with fresh media. If the titer of virus is high, then virtually all fibroblasts will be infected and no selection is required. If the titer is very low, then it is necessary to use a retroviral vector that has a selectable marker, such as neo or his. Once the fibroblasts have been efficiently infected, the fibroblasts are analyzed to determine whether protein is produced.

The engineered fibroblasts are then transplanted onto the host, either alone or after having been grown to confluence on cytodex 3 microcarrier beads.

5 **Example 28 - Gene Therapy Using Endogenous Genes Corresponding To Polynucleotides of the Invention**

Another method of gene therapy according to the present invention involves operably associating the endogenous polynucleotide sequence of the invention with a promoter via homologous recombination as described, for example, in U.S. Patent
10 NO: 5,641,670, issued June 24, 1997; International Publication NO: WO 96/29411, published September 26, 1996; International Publication NO: WO 94/12650, published August 4, 1994; Koller et al., Proc. Natl. Acad. Sci. USA, 86:8932-8935 (1989); and Zijlstra et al., Nature, 342:435-438 (1989). This method involves the activation of a gene which is present in the target cells, but which is not expressed in
15 the cells, or is expressed at a lower level than desired.

Polynucleotide constructs are made which contain a promoter and targeting sequences, which are homologous to the 5' non-coding sequence of endogenous polynucleotide sequence, flanking the promoter. The targeting sequence will be sufficiently near the 5' end of the polynucleotide sequence so the promoter will be
20 operably linked to the endogenous sequence upon homologous recombination. The promoter and the targeting sequences can be amplified using PCR. Preferably, the amplified promoter contains distinct restriction enzyme sites on the 5' and 3' ends. Preferably, the 3' end of the first targeting sequence contains the same restriction enzyme site as the 5' end of the amplified promoter and the 5' end of the second
25 targeting sequence contains the same restriction site as the 3' end of the amplified promoter.

The amplified promoter and the amplified targeting sequences are digested with the appropriate restriction enzymes and subsequently treated with calf intestinal phosphatase. The digested promoter and digested targeting sequences are added
30 together in the presence of T4 DNA ligase. The resulting mixture is maintained under conditions appropriate for ligation of the two fragments. The construct is size fractionated on an agarose gel then purified by phenol extraction and ethanol precipitation.

In this Example, the polynucleotide constructs are administered as naked
35 polynucleotides via electroporation. However, the polynucleotide constructs may also be administered with transfection-facilitating agents, such as liposomes, viral

5 sequences, viral particles, precipitating agents, etc. Such methods of delivery are known in the art.

Once the cells are transfected, homologous recombination will take place which results in the promoter being operably linked to the endogenous polynucleotide sequence. This results in the expression of polynucleotide corresponding to the
10 polynucleotide in the cell. Expression may be detected by immunological staining, or any other method known in the art.

Fibroblasts are obtained from a subject by skin biopsy. The resulting tissue is placed in DMEM + 10% fetal calf serum. Exponentially growing or early stationary phase fibroblasts are trypsinized and rinsed from the plastic surface with nutrient
15 medium. An aliquot of the cell suspension is removed for counting, and the remaining cells are subjected to centrifugation. The supernatant is aspirated and the pellet is resuspended in 5 ml of electroporation buffer (20 mM HEPES pH 7.3, 137 mM NaCl, 5 mM KCl, 0.7 mM Na₂ HPO₄, 6 mM dextrose). The cells are recentrifuged, the supernatant aspirated, and the cells resuspended in electroporation buffer containing 1
20 mg/ml acetylated bovine serum albumin. The final cell suspension contains approximately 3X10⁶ cells/ml. Electroporation should be performed immediately following resuspension.

Plasmid DNA is prepared according to standard techniques. For example, to construct a plasmid for targeting to the locus corresponding to the polynucleotide of
25 the invention, plasmid pUC18 (MBI Fermentas, Amherst, NY) is digested with HindIII. The CMV promoter is amplified by PCR with an XbaI site on the 5' end and a BamHI site on the 3'end. Two non-coding sequences are amplified via PCR: one non-coding sequence (fragment 1) is amplified with a HindIII site at the 5' end and an Xba site at the 3'end; the other non-coding sequence (fragment 2) is amplified with a
30 BamHI site at the 5'end and a HindIII site at the 3'end. The CMV promoter and the fragments (1 and 2) are digested with the appropriate enzymes (CMV promoter - XbaI and BamHI; fragment 1 - XbaI; fragment 2 - BamHI) and ligated together. The resulting ligation product is digested with HindIII, and ligated with the HindIII-digested pUC18 plasmid.

35 Plasmid DNA is added to a sterile cuvette with a 0.4 cm electrode gap (Bio-Rad). The final DNA concentration is generally at least 120 µg/ml. 0.5 ml of the cell

5 suspension (containing approximately 1.5×10^6 cells) is then added to the cuvette, and the cell suspension and DNA solutions are gently mixed. Electroporation is performed with a Gene-Pulser apparatus (Bio-Rad). Capacitance and voltage are set at $960 \mu\text{F}$ and 250-300 V, respectively. As voltage increases, cell survival decreases, but the percentage of surviving cells that stably incorporate the introduced DNA into their
 10 genome increases dramatically. Given these parameters, a pulse time of approximately 14-20 mSec should be observed.

Electroporated cells are maintained at room temperature for approximately 5 min, and the contents of the cuvette are then gently removed with a sterile transfer pipette. The cells are added directly to 10 ml of prewarmed nutrient media (DMEM
 15 with 15% calf serum) in a 10 cm dish and incubated at 37 degree C. The following day, the media is aspirated and replaced with 10 ml of fresh media and incubated for a further 16-24 hours.

The engineered fibroblasts are then injected into the host, either alone or after having been grown to confluence on cytodex 3 microcarrier beads. The fibroblasts
 20 now produce the protein product. The fibroblasts can then be introduced into a patient as described above.

Example 29 - Method of Treatment Using Gene Therapy - In Vivo

Another aspect of the present invention is using in vivo gene therapy methods
 25 to treat disorders, diseases and conditions. The gene therapy method relates to the introduction of naked nucleic acid (DNA, RNA, and antisense DNA or RNA) sequences into an animal to increase or decrease the expression of the polypeptide. The polynucleotide of the present invention may be operatively linked to a promoter or any other genetic elements necessary for the expression of the polypeptide by the
 30 target tissue. Such gene therapy and delivery techniques and methods are known in the art, see, for example, WO90/11092, WO98/11779; U.S. Patent NO. 5693622, 5705151, 5580859; Tabata et al., Cardiovasc. Res. 35(3):470-479 (1997); Chao et al., Pharmacol. Res. 35(6):517-522 (1997); Wolff, Neuromuscul. Disord. 7(5):314-318 (1997); Schwartz et al., Gene Ther. 3(5):405-411 (1996); Tsurumi et al., Circulation
 35 94(12):3281-3290 (1996) (incorporated herein by reference).

The polynucleotide constructs may be delivered by any method that delivers

5 injectable materials to the cells of an animal, such as, injection into the interstitial space of tissues (heart, muscle, skin, lung, liver, intestine and the like). The polynucleotide constructs can be delivered in a pharmaceutically acceptable liquid or aqueous carrier.

The term "naked" polynucleotide, DNA or RNA, refers to sequences that are
10 free from any delivery vehicle that acts to assist, promote, or facilitate entry into the cell, including viral sequences, viral particles, liposome formulations, lipofectin or precipitating agents and the like. However, the polynucleotides of the present invention may also be delivered in liposome formulations (such as those taught in Felgner P.L. et al. (1995) Ann. NY Acad. Sci. 772:126-139 and Abdallah B. et al.
15 (1995) Biol. Cell 85(1):1-7) which can be prepared by methods well known to those skilled in the art.

The polynucleotide vector constructs used in the gene therapy method are preferably constructs that will not integrate into the host genome nor will they contain sequences that allow for replication. Any strong promoter known to those skilled in
20 the art can be used for driving the expression of DNA. Unlike other gene therapies techniques, one major advantage of introducing naked nucleic acid sequences into target cells is the transitory nature of the polynucleotide synthesis in the cells. Studies have shown that non-replicating DNA sequences can be introduced into cells to provide production of the desired polypeptide for periods of up to six months.

25 The polynucleotide construct can be delivered to the interstitial space of tissues within the an animal, including of muscle, skin, brain, lung, liver, spleen, bone marrow, thymus, heart, lymph, blood, bone, cartilage, pancreas, kidney, gall bladder, stomach, intestine, testis, ovary, uterus, rectum, nervous system, eye, gland, and connective tissue. Interstitial space of the tissues comprises the intercellular fluid,
30 mucopolysaccharide matrix among the reticular fibers of organ tissues, elastic fibers in the walls of vessels or chambers, collagen fibers of fibrous tissues, or that same matrix within connective tissue ensheathing muscle cells or in the lacunae of bone. It is similarly the space occupied by the plasma of the circulation and the lymph fluid of the lymphatic channels. Delivery to the interstitial space of muscle tissue is preferred
35 for the reasons discussed below. They may be conveniently delivered by injection into the tissues comprising these cells. They are preferably delivered to and expressed in

5 persistent, non-dividing cells which are differentiated, although delivery and expression may be achieved in non-differentiated or less completely differentiated cells, such as, for example, stem cells of blood or skin fibroblasts. In vivo muscle cells are particularly competent in their ability to take up and express polynucleotides.

For the naked polynucleotide injection, an effective dosage amount of DNA or RNA will be in the range of from about 0.05 g/kg body weight to about 50 mg/kg body weight. Preferably the dosage will be from about 0.005 mg/kg to about 20 mg/kg and more preferably from about 0.05 mg/kg to about 5 mg/kg. Of course, as the artisan of ordinary skill will appreciate, this dosage will vary according to the tissue site of injection. The appropriate and effective dosage of nucleic acid sequence can readily be determined by those of ordinary skill in the art and may depend on the condition being treated and the route of administration. The preferred route of administration is by the parenteral route of injection into the interstitial space of tissues. However, other parenteral routes may also be used, such as, inhalation of an aerosol formulation particularly for delivery to lungs or bronchial tissues, throat or mucous membranes of the nose. In addition, naked polynucleotide constructs can be delivered to arteries during angioplasty by the catheter used in the procedure.

The dose response effects of injected polynucleotide in muscle in vivo is determined as follows. Suitable template DNA for production of mRNA coding for polypeptide of the present invention is prepared in accordance with a standard recombinant DNA methodology. The template DNA, which may be either circular or linear, is either used as naked DNA or complexed with liposomes. The quadriceps muscles of mice are then injected with various amounts of the template DNA.

Five to six week old female and male Balb/C mice are anesthetized by intraperitoneal injection with 0.3 ml of 2.5% Avertin. A 1.5 cm incision is made on the anterior thigh, and the quadriceps muscle is directly visualized. The template DNA is injected in 0.1 ml of carrier in a 1 cc syringe through a 27 gauge needle over one minute, approximately 0.5 cm from the distal insertion site of the muscle into the knee and about 0.2 cm deep. A suture is placed over the injection site for future localization, and the skin is closed with stainless steel clips.

35 After an appropriate incubation time (e.g., 7 days) muscle extracts are
prepared by excising the entire quadriceps. Every fifth 15 μ m cross-section of the

Example 30 - Transgenic Animals.

Any technique known in the art may be used to introduce the transgene (i.e., polynucleotides of the invention) into animals to produce the founder lines of transgenic animals. Such techniques include, but are not limited to, pronuclear microinjection (Paterson et al., Appl. Microbiol. Biotechnol. 40:691-698 (1994); Carver et al., Biotechnology (NY) 11:1263-1270 (1993); Wright et al., Biotechnology (NY) 9:830-834 (1991); and Hoppe et al., U.S. Pat. No. 4,873,191 (1989)); retrovirus mediated gene transfer into germ lines (Van der Putten et al., Proc. Natl. Acad. Sci., USA 82:6148-6152 (1985)), blastocysts or embryos; gene targeting in embryonic stem cells (Thompson et al., Cell 56:313-321 (1989)); electroporation of cells or embryos (Lo, 1983, Mol Cell. Biol. 3:1803-1814 (1983)); introduction of the polynucleotides of the invention using a gene gun (see, e.g., Ulmer et al., Science 259:1745 (1993); introducing nucleic acid constructs into embryonic pluripotent stem cells and transferring the stem cells back into the blastocyst; and sperm-mediated gene transfer (Lavitrano et al., Cell 57:717-723 (1989); etc. For a review of such techniques, see Gordon, "Transgenic Animals," Intl. Rev. Cytol. 115:171-229 (1989),

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5 which is incorporated by reference herein in its entirety.

Any technique known in the art may be used to produce transgenic clones containing polynucleotides of the invention, for example, nuclear transfer into enucleated oocytes of nuclei from cultured embryonic, fetal, or adult cells induced to quiescence (Campell et al., Nature 380:64-66 (1996); Wilmut et al., Nature 385:810-10 813 (1997)).

The present invention provides for transgenic animals that carry the transgene in all their cells, as well as animals which carry the transgene in some, but not all their cells, i.e., mosaic animals or chimeric. The transgene may be integrated as a single transgene or as multiple copies such as in concatamers, e.g., head-to-head tandems or 15 head-to-tail tandems. The transgene may also be selectively introduced into and activated in a particular cell type by following, for example, the teaching of Lasko et al. (Lasko et al., Proc. Natl. Acad. Sci. USA 89:6232-6236 (1992)). The regulatory sequences required for such a cell-type specific activation will depend upon the particular cell type of interest, and will be apparent to those of skill in the art. When it 20 is desired that the polynucleotide transgene be integrated into the chromosomal site of the endogenous gene, gene targeting is preferred. Briefly, when such a technique is to be utilized, vectors containing some nucleotide sequences homologous to the endogenous gene are designed for the purpose of integrating, via homologous recombination with chromosomal sequences, into and disrupting the function of the 25 nucleotide sequence of the endogenous gene. The transgene may also be selectively introduced into a particular cell type, thus inactivating the endogenous gene in only that cell type, by following, for example, the teaching of Gu et al. (Gu et al., Science 265:103-106 (1994)). The regulatory sequences required for such a cell-type specific inactivation will depend upon the particular cell type of interest, and will be apparent 30 to those of skill in the art.

Once transgenic animals have been generated, the expression of the recombinant gene may be assayed utilizing standard techniques. Initial screening may be accomplished by Southern blot analysis or PCR techniques to analyze animal tissues to verify that integration of the transgene has taken place. The level of mRNA 35 expression of the transgene in the tissues of the transgenic animals may also be assessed using techniques which include, but are not limited to, Northern blot analysis

5 of tissue samples obtained from the animal, in situ hybridization analysis, and reverse transcriptase-PCR(RT-PCR).. Samples of transgenic gene-expressing tissue may also be evaluated immunocytochemically or immunohistochemically using antibodies specific for the transgene product.

Once the founder animals are produced, they may be bred, inbred, outbred, or
10 crossbred to produce colonies of the particular animal. Examples of such breeding strategies include, but are not limited to: outbreeding of founder animals with more than one integration site in order to establish separate lines; inbreeding of separate lines in order to produce compound transgenics that express the transgene at higher levels because of the effects of additive expression of each transgene; crossing of
15 heterozygous transgenic animals to produce animals homozygous for a given integration site in order to both augment expression and eliminate the need for screening of animals by DNA analysis; crossing of separate homozygous lines to produce compound heterozygous or homozygous lines; and breeding to place the transgene on a distinct background that is appropriate for an experimental model of
20 interest.

Transgenic animals of the invention have uses which include, but are not limited to, animal model systems useful in elaborating the biological function of polypeptides of the present invention, studying diseases, disorders, and/or conditions associated with aberrant expression, and in screening for compounds effective in
25 ameliorating such diseases, disorders, and/or conditions.

Example 31 - Knock-Out Animals.

Endogenous gene expression can also be reduced by inactivating or "knocking out" the gene and/or its promoter using targeted homologous recombination. (E.g., see
30 Smithies et al., Nature 317:230-234 (1985); Thomas & Capecchi, Cell 51:503-512 (1987); Thompson et al., Cell 5:313-321 (1989); each of which is incorporated by reference herein in its entirety). For example, a mutant, non-functional polynucleotide of the invention (or a completely unrelated DNA sequence) flanked by DNA homologous to the endogenous polynucleotide sequence (either the coding regions or
35 regulatory regions of the gene) can be used, with or without a selectable marker and/or a negative selectable marker, to transfect cells that express polypeptides of the

5 invention in vivo. In another embodiment, techniques known in the art are used to generate knockouts in cells that contain, but do not express the gene of interest. Insertion of the DNA construct, via targeted homologous recombination, results in inactivation of the targeted gene. Such approaches are particularly suited in research and agricultural fields where modifications to embryonic stem cells can be used to
10 generate animal offspring with an inactive targeted gene (e.g., see Thomas & Capecchi 1987 and Thompson 1989, supra). However this approach can be routinely adapted for use in humans provided the recombinant DNA constructs are directly administered or targeted to the required site in vivo using appropriate viral vectors that will be apparent to those of skill in the art.

15 In further embodiments of the invention, cells that are genetically engineered to express the polypeptides of the invention, or alternatively, that are genetically engineered not to express the polypeptides of the invention (e.g., knockouts) are administered to a patient in vivo. Such cells may be obtained from the patient (i.e., animal, including human) or an MHC compatible donor and can include, but are not
20 limited to fibroblasts, bone marrow cells, blood cells (e.g., lymphocytes), adipocytes, muscle cells, endothelial cells etc. The cells are genetically engineered in vitro using recombinant DNA techniques to introduce the coding sequence of polypeptides of the invention into the cells, or alternatively, to disrupt the coding sequence and/or endogenous regulatory sequence associated with the polypeptides of the invention,
25 e.g., by transduction (using viral vectors, and preferably vectors that integrate the transgene into the cell genome) or transfection procedures, including, but not limited to, the use of plasmids, cosmids, YACs, naked DNA, electroporation, liposomes, etc. The coding sequence of the polypeptides of the invention can be placed under the control of a strong constitutive or inducible promoter or promoter/enhancer to achieve
30 expression, and preferably secretion, of the polypeptides of the invention. The engineered cells which express and preferably secrete the polypeptides of the invention can be introduced into the patient systemically, e.g., in the circulation, or intraperitoneally.

Alternatively, the cells can be incorporated into a matrix and implanted in the
35 body, e.g., genetically engineered fibroblasts can be implanted as part of a skin graft; genetically engineered endothelial cells can be implanted as part of a lymphatic or

5 vascular graft. (See, for example, Anderson et al. U.S. Patent No. 5,399,349; and
Mulligan & Wilson, U.S. Patent No. 5,460,959 each of which is incorporated by
reference herein in its entirety).

When the cells to be administered are non-autologous or non-MHC
compatible cells, they can be administered using well known techniques which
10 prevent the development of a host immune response against the introduced cells. For
example, the cells may be introduced in an encapsulated form which, while allowing
for an exchange of components with the immediate extracellular environment, does
not allow the introduced cells to be recognized by the host immune system.

Transgenic and "knock-out" animals of the invention have uses which include,
15 but are not limited to, animal model systems useful in elaborating the biological
function of polypeptides of the present invention, studying diseases, disorders, and/or
conditions associated with aberrant expression, and in screening for compounds
effective in ameliorating such diseases, disorders, and/or conditions.

20 **Example 32 - Production of an Antibody**

a) Hybridoma Technology

The antibodies of the present invention can be prepared by a variety of
methods. (See, Current Protocols, Chapter 2.) As one example of such methods, cells
expressing K+betaM4 or K+betaM5 are administered to an animal to induce the
25 production of sera containing polyclonal antibodies. In a preferred method, a
preparation of K+betaM4 or K+betaM5 protein is prepared and purified to render it
substantially free of natural contaminants. Such a preparation is then introduced into
an animal in order to produce polyclonal antisera of greater specific activity.

Monoclonal antibodies specific for protein K+betaM4 or K+betaM5 are
30 prepared using hybridoma technology. (Kohler et al., Nature 256:495 (1975); Kohler
et al., Eur. J. Immunol. 6:511 (1976); Kohler et al., Eur. J. Immunol. 6:292 (1976);
Hammerling et al., in: Monoclonal Antibodies and T-Cell Hybridomas, Elsevier,
N.Y., pp. 563-681 (1981)). In general, an animal (preferably a mouse) is immunized
with K+betaM4 or K+betaM5 polypeptide or, more preferably, with a secreted
35 K+betaM4 or K+betaM5 polypeptide-expressing cell. Such polypeptide-expressing
cells are cultured in any suitable tissue culture medium, preferably in Earle's modified

5 Eagle's medium supplemented with 10% fetal bovine serum (inactivated at about 56°C), and supplemented with about 10 g/l of nonessential amino acids, about 1,000 U/ml of penicillin, and about 100 µg/ml of streptomycin.

The splenocytes of such mice are extracted and fused with a suitable myeloma cell line. Any suitable myeloma cell line may be employed in accordance with the present invention; however, it is preferable to employ the parent myeloma cell line (SP2O), available from the ATCC. After fusion, the resulting hybridoma cells are selectively maintained in HAT medium, and then cloned by limiting dilution as described by Wands et al. (Gastroenterology 80:225-232 (1981)). The hybridoma cells obtained through such a selection are then assayed to identify clones which
15 secrete antibodies capable of binding the K+betaM4 or K+betaM5 polypeptide.

Alternatively, additional antibodies capable of binding to K+betaM4 or K+betaM5 polypeptide can be produced in a two-step procedure using anti-idiotypic antibodies. Such a method makes use of the fact that antibodies are themselves antigens, and therefore, it is possible to obtain an antibody which binds to a second
20 antibody. In accordance with this method, protein specific antibodies are used to immunize an animal, preferably a mouse. The splenocytes of such an animal are then used to produce hybridoma cells, and the hybridoma cells are screened to identify clones which produce an antibody whose ability to bind to the K+betaM4 or K+betaM5 protein-specific antibody can be blocked by K+betaM4 or K+betaM5.
25 Such antibodies comprise anti-idiotypic antibodies to the K+betaM4 or K+betaM5 protein-specific antibody and are used to immunize an animal to induce formation of further K+betaM4 or K+betaM5 protein-specific antibodies.

For in vivo use of antibodies in humans, an antibody is "humanized". Such antibodies can be produced using genetic constructs derived from hybridoma cells
30 producing the monoclonal antibodies described above. Methods for producing chimeric and humanized antibodies are known in the art and are discussed herein. (See, for review, Morrison, Science 229:1202 (1985); Oi et al., BioTechniques 4:214 (1986); Cabilly et al., U.S. Patent No. 4,816,567; Taniguchi et al., EP 171496; Morrison et al., EP 173494; Neuberger et al., WO 8601533; Robinson et al., WO
35 8702671; Boulianne et al., Nature 312:643 (1984); Neuberger et al., Nature 314:268 (1985).)

5 b) Isolation Of Antibody Fragments Directed

 Against K+betaM4 or K+betaM5 From A Library Of scFvs

 Naturally occurring V-genes isolated from human PBLs are constructed into a library of antibody fragments which contain reactivities against K+betaM4 or K+betaM5 to which the donor may or may not have been exposed (see e.g., U.S. Patent 5,885,793 incorporated herein by reference in its entirety).

 Rescue of the Library. A library of scFvs is constructed from the RNA of human PBLs as described in PCT publication WO 92/01047. To rescue phage displaying antibody fragments, approximately 10⁹ E. coli harboring the phagemid are used to inoculate 50 ml of 2xTY containing 1% glucose and 100 µg/ml of ampicillin (2xTY-AMP-GLU) and grown to an O.D. of 0.8 with shaking. Five ml of this culture is used to inoculate 50 ml of 2xTY-AMP-GLU, 2 x 10⁸ TU of delta gene 3 helper (M13 delta gene III, see PCT publication WO 92/01047) are added and the culture incubated at 37°C for 45 minutes without shaking and then at 37°C for 45 minutes with shaking. The culture is centrifuged at 4000 r.p.m. for 10 min. and the pellet resuspended in 2 liters of 2xTY containing 100 µg/ml ampicillin and 50 ug/ml kanamycin and grown overnight. Phage are prepared as described in PCT publication WO 92/01047.

 M13 delta gene III is prepared as follows: M13 delta gene III helper phage does not encode gene III protein, hence the phage(mid) displaying antibody fragments have a greater avidity of binding to antigen. Infectious M13 delta gene III particles are made by growing the helper phage in cells harboring a pUC19 derivative supplying the wild type gene III protein during phage morphogenesis. The culture is incubated for 1 hour at 37° C without shaking and then for a further hour at 37°C with shaking. Cells are spun down (IEC-Centra 8,400 r.p.m. for 10 min), resuspended in 300 ml 2xTY broth containing 100 µg ampicillin/ml and 25 µg kanamycin/ml (2xTY-AMP-KAN) and grown overnight, shaking at 37°C. Phage particles are purified and concentrated from the culture medium by two PEG-precipitations (Sambrook et al., 1990), resuspended in 2 ml PBS and passed through a 0.45 µm filter (Minisart NML; Sartorius) to give a final concentration of approximately 10¹³ transducing units/ml (ampicillin-resistant clones).

 Panning of the Library. Immunotubes (Nunc) are coated overnight in PBS

5 with 4 ml of either 100 µg/ml or 10 µg/ml of a polypeptide of the present invention. Tubes are blocked with 2% Marvel-PBS for 2 hours at 37°C and then washed 3 times in PBS. Approximately 10¹³ TU of phage is applied to the tube and incubated for 30 minutes at room temperature tumbling on an over and under turntable and then left to stand for another 1.5 hours. Tubes are washed 10 times with PBS 0.1% Tween-20 and
10 10 times with PBS. Phage are eluted by adding 1 ml of 100 mM triethylamine and rotating 15 minutes on an under and over turntable after which the solution is immediately neutralized with 0.5 ml of 1.0M Tris-HCl, pH 7.4. Phage are then used to infect 10 ml of mid-log E. coli TG1 by incubating eluted phage with bacteria for 30 minutes at 37°C. The E. coli are then plated on TYE plates containing 1% glucose and
15 100 µg/ml ampicillin. The resulting bacterial library is then rescued with delta gene 3 helper phage as described above to prepare phage for a subsequent round of selection. This process is then repeated for a total of 4 rounds of affinity purification with tube-washing increased to 20 times with PBS, 0.1% Tween-20 and 20 times with PBS for rounds 3 and 4.

20 Characterization of Binders. Eluted phage from the 3rd and 4th rounds of selection are used to infect E. coli HB 2151 and soluble scFv is produced (Marks, et al., 1991) from single colonies for assay. ELISAs are performed with microtitre plates coated with either 10 pg/ml of the polypeptide of the present invention in 50 mM bicarbonate pH 9.6. Clones positive in ELISA are further characterized by PCR
25 fingerprinting (see, e.g., PCT publication WO 92/01047) and then by sequencing. These ELISA positive clones may also be further characterized by techniques known in the art, such as, for example, epitope mapping, binding affinity, receptor signal transduction, ability to block or competitively inhibit antibody/antigen binding, and competitive agonistic or antagonistic activity.

30

Example 33 - Identification and Cloning of VH and VL domains Of Antibodies Directed Against the K+betaM4 or K+betaM5 Polypeptides.

VH and VL domains may be identified and cloned from cell lines expressing an antibody directed against a K+betaM4 or K+betaM5 or K+betaM5 epitope by
35 performing PCR with VH and VL specific primers on cDNA made from the antibody expressing cell lines. Briefly, RNA is isolated from the cell lines and used as a

5 template for RT-PCR designed to amplify the VH and VL domains of the antibodies expressed by the EBV cell lines. Cells may be lysed using the TRIzol reagent (Life Technologies, Rockville, MD) and extracted with one fifth volume of chloroform. After addition of chloroform, the solution is allowed to incubate at room temperature for 10 minutes, and then centrifuged at 14, 000 rpm for 15 minutes at 4 C in a tabletop
10 centrifuge. The supernatant is collected and RNA is precipitated using an equal volume of isopropanol. Precipitated RNA is pelleted by centrifuging at 14, 000 rpm for 15 minutes at 4 C in a tabletop centrifuge.

Following centrifugation, the supernatant is discarded and washed with 75% ethanol. Following the wash step, the RNA is centrifuged again at 800 rpm for 5
15 minutes at 4 C. The supernatant is discarded and the pellet allowed to air dry. RNA is dissolved in DEPC water and heated to 60 C for 10 minutes. Quantities of RNA can be determined using optical density measurements. CDNA may be synthesized, according to methods well-known in the art and/or described herein, from 1. 5-2. 5 micrograms of RNA using reverse transcriptase and random hexamer primers. CDNA
20 is then used as a template for PCR amplification of VH and VL domains.

Primers used to amplify VH and VL genes are shown below. Typically a PCR reaction makes use of a single 5'primer and a single 3'primer. Sometimes, when the amount of available RNA template is limiting, or for greater efficiency, groups of 5' and/or 3'primers may be used. For example, sometimes all five VH-5'primers and all
25 JH3'primers are used in a single PCR reaction. The PCR reaction is carried out in a 50 microliter volume containing 1X PCR buffer, 2mM of each dNTP, 0. 7 units of High Fidelity Taq polymerase, 5'primer mix, 3'primer mix and 7. 5 microliters of cDNA. The 5'and 3'primer mix of both VH and VL can be made by pooling together 22 pmole and 28 pmole, respectively, of each of the individual primers. PCR
30 conditions are : 96 C for 5 minutes ; followed by 25 cycles of 94 C for 1 minute, 50 C for 1 minute, and 72 C for 1 minute ; followed by an extension cycle of 72 C for 10 minutes. After the reaction has been completed, sample tubes may be stored at 4 C.

Primer Sequences Used to Amplify VH domains.

Primer name	Primer Sequence	SEQ ID NO:
Hu VH1 – 5'	CAGGTGCAGCTGGTGCAGTCTGG	58
Hu VH2 – 5'	CAGGTCAACTTAAGGGAGTCTGG	59
Hu VH3 – 5'	GAGGTGCAGCTGGTGGAGTCTGG	60

Hu VH4 – 5'	CAGGTGCAGCTGCAGGAGTCGGG	61
Hu VH5 – 5'	GAGGTGCAGCTGTTGCAGTCTGC	62
Hu VH6 – 5'	CAGGTACAGCTGCAGCAGTCAGG	63
Hu JH1 – 5'	TGAGGAGACGGTGACCAGGGTGCC	64
Hu JH3 – 5'	TGAAGAGACGGTGACCATTGTCCC	65
Hu JH4 – 5'	TGAGGAGACGGTGACCAGGGTTCC	66
Hu JH6 – 5'	TGAGGAGACGGTGACCGTGGTCCC	67

5

Primer Sequences Used to Amplify VL domains

Primer name	Primer Sequence	SEQ NO:	ID
Hu Vkappa1 – 5'	GACATCCAGATGACCCAGTCTCC	68	
Hu Vkappa2a – 5'	GATGTTGTGATGACTCAGTCTCC	69	
Hu Vkappa2b – 5'	GATATTGTGATGACTCAGTCTCC	70	
Hu Vkappa3 – 5'	GAAATTGTGTTGACGCAGTCTCC	71	
Hu Vkappa4 – 5'	GACATCGTGATGACCCAGTCTCC	72	
Hu Vkappa5 – 5'	GAAACGACACTCACGCAGTCTCC	73	
Hu Vkappa6 – 5'	GAAATTGTGCTGACTCAGTCTCC	74	
Hu Vlambdal – 5'	CAGTCTGTGTTGACGCAGCCGCC	75	
Hu Vlambda2 – 5'	CAGTCTGCCCTGACTCAGCCTGC	76	
Hu Vlambda3 – 5'	TCCTATGTGCTGACTCAGCCACC	77	
Hu Vlambda3b – 5'	TCTTCTGAGCTGACTCAGGACCC	78	
Hu Vlambda4 – 5'	CACGTTATACTGACTCAACCGCC	79	
Hu Vlambda5 – 5'	CAGGCTGTGCTCACTCAGCCGTC	80	
Hu Vlambda6 – 5'	AATTTTATGCTGACTCAGCCCCA	81	
Hu Jkappa1 – 3'	ACGTTTGATTTCCACCTTGGTCCC	82	
Hu Jkappa2 – 3'	ACGTTTGATCTCCAGCTTGGTCCC	83	
Hu Jkappa3 – 3'	ACGTTTGATATCCACTTGGTCCC	84	
Hu Jkappa4 – 3'	ACGTTTGATCTCCACCTTGGTCCC	85	
Hu Jkappa5 – 3'	ACGTTTAATCTCCAGTCGTGTC	86	
Hu Vlambdal – 3'	CAGTCTGTGTTGACGCAGCCGCC	87	
Hu Vlambda2 – 3'	CAGTCTGCCCTGACTCAGCCTGC	88	
Hu Vlambda3 – 3'	TCCTATGTGCTGACTCAGCCACC	89	
Hu Vlambda3b – 3'	TCTTCTGAGCTGACTCAGGACCC	90	
Hu Vlambda4 – 3'	CACGTTATACTGACTCAACCGCC	91	
Hu Vlambda5 – 3'	CAGGCTGTGCTCACTCAGCCGTC	92	
Hu Vlambda6 – 3'	AATTTTATGCTGACTCAGCCCCA	93	

10 PCR samples are then electrophoresed on a 1.3% agarose gel. DNA bands of the expected sizes (~506 base pairs for VH domains, and 344 base pairs for VL domains) can be cut out of the gel and purified using methods well known in the art and/or described herein.

15 Purified PCR products can be ligated into a PCR cloning vector (TA vector from Invitrogen Inc., Carlsbad, CA). Individual cloned PCR products can be isolated after transfection of E. coli and blue/white color selection. Cloned PCR products may then be sequenced using methods commonly known in the art and/or described herein.

5 The PCR bands containing the VH domain and the VL domains can also be used to create full-length Ig expression vectors. VH and VL domains can be cloned into vectors containing the nucleotide sequences of a heavy (e. g., human IgG1 or human IgG4) or light chain (human kappa or human lambda) constant regions such that a complete heavy or light chain molecule could be expressed from these vectors
10 when transfected into an appropriate host cell. Further, when cloned heavy and light chains are both expressed in one cell line (from either one or two vectors), they can assemble into a complete functional antibody molecule that is secreted into the cell culture medium. Methods using polynucleotides encoding VH and VL antibody domain to generate expression vectors that encode complete antibody molecules are
15 well known within the art.

Example 34 – Method of Creating N- and C-terminal Deletion Mutants Corresponding to the K+betaM4 and K+betaM5 Polypeptides of the Present Invention.

20 As described elsewhere herein, the present invention encompasses the creation of N- and C-terminal deletion mutants, in addition to any combination of N- and C-terminal deletions thereof, corresponding to the K+betaM4 and K+betaM5 polypeptides of the present invention. A number of methods are available to one skilled in the art for creating such mutants. Such methods may include a combination
25 of PCR amplification and gene cloning methodology. Although one of skill in the art of molecular biology, through the use of the teachings provided or referenced herein, and/or otherwise known in the art as standard methods, could readily create each deletion mutant of the present invention, exemplary methods are described below.

 Briefly, using the isolated cDNA clone encoding the full-length K+betaM4 or
30 K+betaM5 or K+betaM5 polypeptide sequence (as described in Example 11, for example), appropriate primers of about 15-25 nucleotides derived from the desired 5' and 3' positions of SEQ ID NO:1, or SEQ ID NO:23 may be designed to PCR amplify, and subsequently clone, the intended N- and/or C-terminal deletion mutant. Such primers could comprise, for example, an initiation and stop codon for the 5' and
35 3' primer, respectively. Such primers may also comprise restriction sites to facilitate cloning of the deletion mutant post amplification. Moreover, the primers may

- 5 comprise additional sequences, such as, for example, flag-tag sequences, kozac sequences, or other sequences discussed and/or referenced herein.

For example, in the case of the S93 to R351 K+betaM4 N-terminal deletion mutant, the following primers could be used to amplify a cDNA fragment corresponding to this deletion mutant:

10

5' Primer	5'-GCAGCA <u>GCGGCCGC</u> TCCGACCCCATCACGCTGAACGTCG -3' (SEQ ID NO.94) <i>NotI</i>
3' Primer	5'- GCAGCA <u>GTCGAC</u> CCTGTACCGTATTAATCGAATAATC -3' (SEQ ID NO.95) <i>Sall</i>

For example, in the case of the M1 to N259 K+betaM4 C-terminal deletion mutant, the following primers could be used to amplify a cDNA fragment corresponding to this deletion mutant:

15

5' Primer	5'- GCAGCA <u>GCGGCCGC</u> ATGACCGGGAGCCATGACGTCATCG -3' (SEQ ID NO.96) <i>NotI</i>
3' Primer	5'- GCAGCA <u>GTCGAC</u> ATTGGAGCAGTAGAAGAGCTTAGAG -3' (SEQ ID NO.97) <i>Sall</i>

For example, in the case of the G14 to G343 K+betaM5 N-terminal deletion mutant, the following primers could be used to amplify a cDNA fragment corresponding to this deletion mutant:

20

5' Primer	5'-GCAGCA <u>GCGGCCGC</u> GGACCACTCAGGCGCCGCCGCTGG-3' (SEQ ID NO.41) <i>NotI</i>
3' Primer	5'- GCAGCA <u>GTCGAC</u> GCCCATGAAGTGTGGAATACTCCTG-3' (SEQ ID NO.42) <i>Sall</i>

For example, in the case of the M1 to Q275 K+betaM5 C-terminal deletion mutant, the following primers could be used to amplify a cDNA fragment corresponding to this deletion mutant:

25

5' Primer	5'- GCAGCA <u>GCGGCCGC</u> ATGACGATGGCGGTTTTGCGGAATAGAAAAGGGGG-3' (SEQ ID NO 43) <i>NotI</i>
3' Primer	5'- GCAGCA <u>GTCGAC</u> CTGGACCGCACGCAGCCGGGCGATCTCC-3' (SEQ ID NO:44) <i>Sall</i>

5

Representative PCR amplification conditions are provided below, although the skilled artisan would appreciate that other conditions may be required for efficient amplification. A 100 ul PCR reaction mixture may be prepared using 10ng of the template DNA (cDNA clone of K+betaM5), 200 uM 4dNTPs, 1uM primers, 0.25U
 10 Taq DNA polymerase (PE), and standard Taq DNA polymerase buffer. Typical PCR cycling condition are as follows:

20-25 cycles: 45 sec, 93 degrees
 2 min, 50 degrees
 2 min, 72 degrees
 15 1 cycle: 10 min, 72 degrees

After the final extension step of PCR, 5U Klenow Fragment may be added and incubated for 15 min at 30 degrees.

20 Upon digestion of the fragment with the NotI and Sall restriction enzymes, the fragment could be cloned into an appropriate expression and/or cloning vector which has been similarly digested (e.g., pSport1, among others). The skilled artisan would appreciate that other plasmids could be equally substituted, and may be desirable in certain circumstances. The digested fragment and vector are then ligated using a DNA
 25 ligase, and then used to transform competent E.coli cells using methods provided herein and/or otherwise known in the art.

The 5' primer sequence for amplifying any additional N-terminal deletion mutants may be determined by reference to the following formula:

30 $(S+(X * 3))$ to $((S+(X * 3))+25)$, wherein 'S' is equal to the nucleotide position of the initiating start codon of the K+betaM4 or K+betaM5 gene (SEQ ID NO:1, or SEQ ID NO:23), and 'X' is equal to the most N-terminal amino acid of the intended N-terminal deletion mutant. The first term will provide the start 5' nucleotide position of the 5' primer, while the second term will provide the end 3'

5 nucleotide position of the 5' primer corresponding to sense strand of SEQ ID NO:1, or SEQ ID NO:23. Once the corresponding nucleotide positions of the primer are determined, the final nucleotide sequence may be created by the addition of applicable restriction site sequences to the 5' end of the sequence, for example. As referenced herein, the addition of other sequences to the 5' primer may be desired in
10 certain circumstances (e.g., kozac sequences, etc.).

The 3' primer sequence for amplifying any additional N-terminal deletion mutants may be determined by reference to the following formula:

(S+(X * 3)) to ((S+(X * 3))-25), wherein 'S' is equal to the nucleotide position of the initiating start codon of the K+betaM4 or K+betaM5 gene (SEQ ID NO:1, or
15 SEQ ID NO:23), and 'X' is equal to the most C-terminal amino acid of the intended N-terminal deletion mutant. The first term will provide the start 5' nucleotide position of the 3' primer, while the second term will provide the end 3' nucleotide position of the 3' primer corresponding to the anti-sense strand of SEQ ID NO:1, or SEQ ID NO:23. Once the corresponding nucleotide positions of the primer are determined, the
20 final nucleotide sequence may be created by the addition of applicable restriction site sequences to the 5' end of the sequence, for example. As referenced herein, the addition of other sequences to the 3' primer may be desired in certain circumstances (e.g., stop codon sequences, etc.). The skilled artisan would appreciate that modifications of the above nucleotide positions may be necessary for optimizing PCR
25 amplification.

The same general formulas provided above may be used in identifying the 5' and 3' primer sequences for amplifying any C-terminal deletion mutant of the present invention. Moreover, the same general formulas provided above may be used in identifying the 5' and 3' primer sequences for amplifying any combination of N-
30 terminal and C-terminal deletion mutant of the present invention. The skilled artisan would appreciate that modifications of the above nucleotide positions may be necessary for optimizing PCR amplification.

Example 35 - Biological Effects of Polypeptides of the Invention

35 Astrocyte and Neuronal Assays.

Recombinant polypeptides of the invention, expressed in Escherichia coli and

5 purified as described above, can be tested for activity in promoting the survival, neurite outgrowth, or phenotypic differentiation of cortical neuronal cells and for inducing the proliferation of glial fibrillary acidic protein immunopositive cells, astrocytes. The selection of cortical cells for the bioassay is based on the prevalent expression of FGF-1 and FGF-2 in cortical structures and on the previously reported
10 enhancement of cortical neuronal survival resulting from FGF-2 treatment. A thymidine incorporation assay, for example, can be used to elucidate a polypeptide of the invention's activity on these cells.

Moreover, previous reports describing the biological effects of FGF-2 (basic FGF) on cortical or hippocampal neurons in vitro have demonstrated increases in both
15 neuron survival and neurite outgrowth (Walicke et al., "Fibroblast growth factor promotes survival of dissociated hippocampal neurons and enhances neurite extension." Proc. Natl. Acad. Sci. USA 83:3012-3016. (1986), assay herein incorporated by reference in its entirety). However, reports from experiments done on PC-12 cells suggest that these two responses are not necessarily synonymous and may
20 depend on not only which FGF is being tested but also on which receptor(s) are expressed on the target cells. Using the primary cortical neuronal culture paradigm, the ability of a polypeptide of the invention to induce neurite outgrowth can be compared to the response achieved with FGF-2 using, for example, a thymidine incorporation assay.

25

Fibroblast and endothelial cell assays.

Human lung fibroblasts are obtained from Clonetics (San Diego, CA) and maintained in growth media from Clonetics. Dermal microvascular endothelial cells are obtained from Cell Applications (San Diego, CA). For proliferation assays, the
30 human lung fibroblasts and dermal microvascular endothelial cells can be cultured at 5,000 cells/well in a 96-well plate for one day in growth medium. The cells are then incubated for one day in 0.1% BSA basal medium. After replacing the medium with fresh 0.1% BSA medium, the cells are incubated with the test proteins for 3 days. Alamar Blue (Alamar Biosciences, Sacramento, CA) is added to each well to a final
35 concentration of 10%. The cells are incubated for 4 hr. Cell viability is measured by reading in a CytoFluor fluorescence reader. For the PGE2 assays, the human lung

5 fibroblasts are cultured at 5,000 cells/well in a 96-well plate for one day. After a medium change to 0.1% BSA basal medium, the cells are incubated with FGF-2 or polypeptides of the invention with or without IL-1(for 24 hours. The supernatants are collected and assayed for PGE2 by EIA kit (Cayman, Ann Arbor, MI). For the IL-6 assays, the human lung fibroblasts are cultured at 5,000 cells/well in a 96-well plate
10 for one day. After a medium change to 0.1% BSA basal medium, the cells are incubated with FGF-2 or with or without polypeptides of the invention IL-1(for 24 hours. The supernatants are collected and assayed for IL-6 by ELISA kit (Endogen, Cambridge, MA).

Human lung fibroblasts are cultured with FGF-2 or polypeptides of the
15 invention for 3 days in basal medium before the addition of Alamar Blue to assess effects on growth of the fibroblasts. FGF-2 should show a stimulation at 10 - 2500 ng/ml which can be used to compare stimulation with polypeptides of the invention.

Parkinson Models.

20 The loss of motor function in Parkinson's disease is attributed to a deficiency of striatal dopamine resulting from the degeneration of the nigrostriatal dopaminergic projection neurons. An animal model for Parkinson's that has been extensively characterized involves the systemic administration of 1-methyl-4 phenyl 1,2,3,6-tetrahydropyridine (MPTP). In the CNS, MPTP is taken-up by astrocytes and
25 catabolized by monoamine oxidase B to 1-methyl-4-phenyl pyridine (MPP+) and released. Subsequently, MPP+ is actively accumulated in dopaminergic neurons by the high-affinity reuptake transporter for dopamine. MPP+ is then concentrated in mitochondria by the electrochemical gradient and selectively inhibits nicotinamide adenine disphosphate: ubiquinone oxidoreductionase (complex I), thereby interfering
30 with electron transport and eventually generating oxygen radicals.

It has been demonstrated in tissue culture paradigms that FGF-2 (basic FGF) has trophic activity towards nigral dopaminergic neurons (Ferrari et al., Dev. Biol. 1989). Recently, Dr. Unsicker's group has demonstrated that administering FGF-2 in gel foam implants in the striatum results in the near complete protection of nigral
35 dopaminergic neurons from the toxicity associated with MPTP exposure (Otto and Unsicker, J. Neuroscience, 1990).

5 Based on the data with FGF-2, polypeptides of the invention can be evaluated to determine whether it has an action similar to that of FGF-2 in enhancing dopaminergic neuronal survival in vitro and it can also be tested in vivo for protection of dopaminergic neurons in the striatum from the damage associated with MPTP treatment. The potential effect of a polypeptide of the invention is first examined in
10 vitro in a dopaminergic neuronal cell culture paradigm. The cultures are prepared by dissecting the midbrain floor plate from gestation day 14 Wistar rat embryos. The tissue is dissociated with trypsin and seeded at a density of 200,000 cells/cm² on polyorthinine-laminin coated glass coverslips. The cells are maintained in Dulbecco's Modified Eagle's medium and F12 medium containing hormonal supplements (N1).
15 The cultures are fixed with paraformaldehyde after 8 days in vitro and are processed for tyrosine hydroxylase, a specific marker for dopaminergic neurons, immunohistochemical staining. Dissociated cell cultures are prepared from embryonic rats. The culture medium is changed every third day and the factors are also added at that time.

20 Since the dopaminergic neurons are isolated from animals at gestation day 14, a developmental time which is past the stage when the dopaminergic precursor cells are proliferating, an increase in the number of tyrosine hydroxylase immunopositive neurons would represent an increase in the number of dopaminergic neurons surviving in vitro. Therefore, if a polypeptide of the invention acts to prolong the
25 survival of dopaminergic neurons, it would suggest that the polypeptide may be involved in Parkinson's Disease.

 One skilled in the art could easily modify the exemplified studies to test the activity of polynucleotides of the invention (e.g., gene therapy), agonists, and/or antagonists of polynucleotides or polypeptides of the invention.

30 One skilled in the art could easily modify the exemplified studies to test the activity of polynucleotides of the invention (e.g., gene therapy), agonists, and/or antagonists of polynucleotides or polypeptides of the invention.

 It will be clear that the invention may be practiced otherwise than as particularly described in the foregoing description and examples. Numerous
35 modifications and variations of the present invention are possible in light of the above teachings and, therefore, are within the scope of the appended claims.

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5 The entire disclosure of each document cited (including patents, patent applications, journal articles, abstracts, laboratory manuals, books, or other disclosures) in the Background of the Invention, Detailed Description, and Examples is hereby incorporated herein by reference. Further, the hard copy of the sequence listing submitted herewith and the corresponding computer readable form are both
10 incorporated herein by reference in their entireties.